DOCUMENT RESUME

ED 255 532 TM 840 683

AUTHOR	Spottheim, David; And Others
TITLE	Public Education Resources and Pupil Performance Models.
INSTITUTION	Long Island Regional Planning Board, Hauppauge, NY.
PUB DATE	Aug 84
NOTE	163p.; For related document, see TM 840 682. Tables and appendices contain small print.
PUB TYPE	Reports - Research/Technical (143)
EDRS PRICE	MF01/PC07 Plus Postage.
DESCRIPTORS	*Academic Achievement; Decision Making; Educational Finance; *Educational Objectives; Elementary Secondary Education; Equal Education; Input Output Analysis; Linear Programing; *Mathematical Models; *Resource Allocation; *School Districts; Simulation; Systems Approach
IDENTIFIERS	*Pupil Performance Models

ABSTRACT

This report details three models quantifying the relationships between educational means (resources) and ends (pupil achievements) to analyze resource allocation problems within school districts: (1) the Pupil Performance Model; (2) the Goal Programming Model; and (3) the Operational Structure of a School and Pupil Performance Model. These models reduce educational data to manageable equations through the application of educational economic concepts and quantitative methods. They can be used to address two of New York state's major educational policy predicaments: (1) What is the best composition of financial resources (by function) to produce predetermined levels of educational ends in a given type of school district while considering its pupil and community attributes? and (2) What administrative adjustments can be implemented by a given educational jurisdiction to attain some predetermined (and unified) educational goals for an array of pupils with diverse attributes? A 33-item bibliography is included. (BS)

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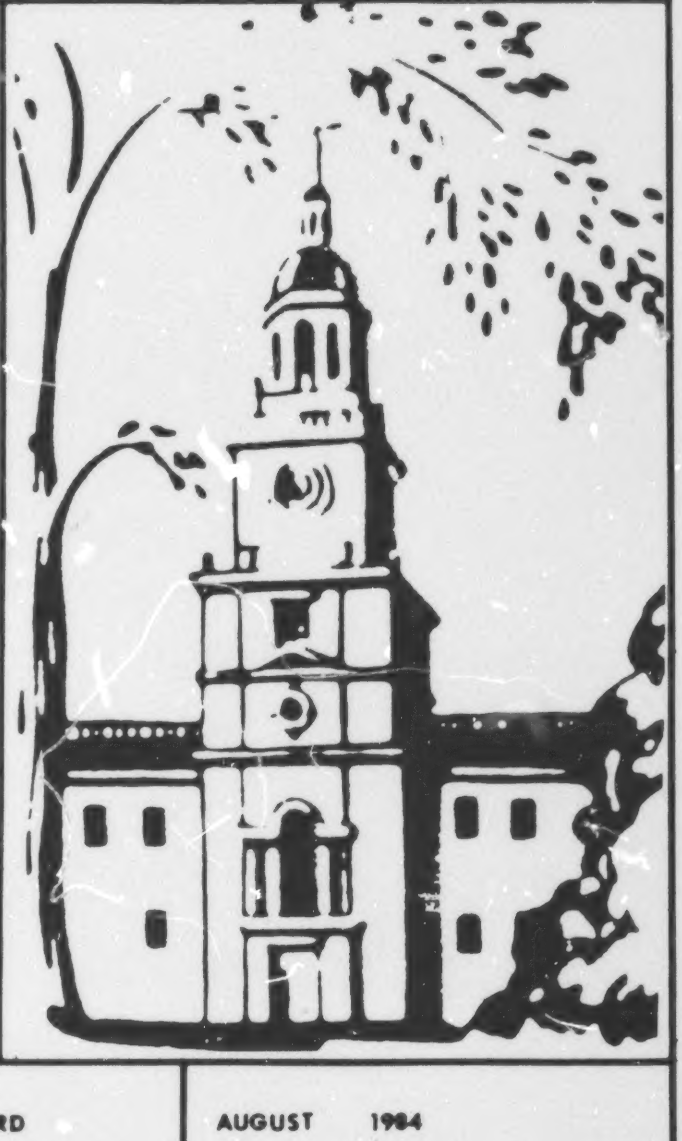

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HAUPPAUGE, NEW YORK

AUGUST 1984

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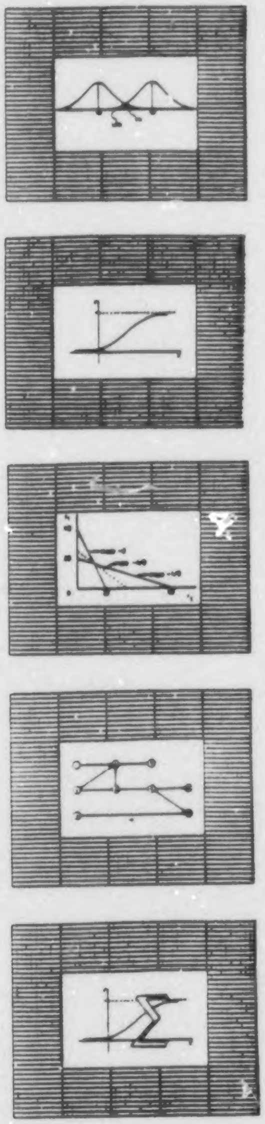

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*Research for this report was supported by a grant initiated by The Honorable Kenneth A. LaValle, New York State Senator, 1st District.

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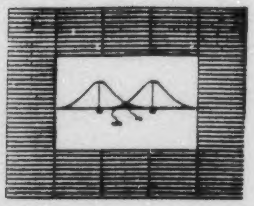
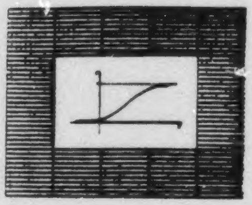


RESEARCH & DEVELOPMENT

David Spottheim
Paul C. Libassi
George R. Wilson



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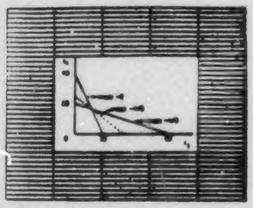

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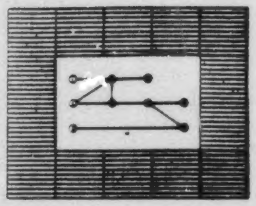

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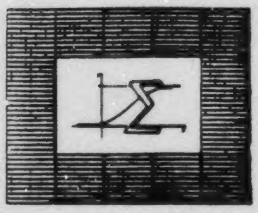

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ACKNOWLEDGEMENTS

Several people deserve an acknowledgement for the substance and detail presented in this report. A special thanks to the Honorable Kenneth A. LaValle and James H. Donovan, New York State Senators; and William Gosch and Richard Pfister, New York State Senate staff, for encouragement and support. Thanks are also due to various members of the N.Y.S. Education Department; Lois Wilson, Thomas J. Malesky and David Clapp, as well as a former member - Dr. Robert Lamitie, and others for their assistance.

Thanks to reviewers whose comments and suggestions were valuable: Dr. Vern Farewell (Fred Hutchison Research Center) who reviewed material presented in Chapter II; Dr. Ben Hobbs (Case Institute) who commented on matters concerning Chapter III, and Dr. Roger Pujacki (SUNY, Stony Brook) who assisted us to activate computer packages.

Also, acknowledgement goes to several educators: Dr. Charles W. Rudiger and Dr. Lester Dubnick (Huntington School District), Dr. Gerald LaMantia (BOCES I), and Mr. David Holt (Brentwood School District) for their support in obtaining the necessary data for the simulations presented in Chapters III and IV. A deep and unique sense of appreciation is due to the members of the Long Island Regional Planning Board and the Advisory Committee of this project for their support.

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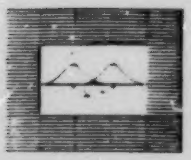
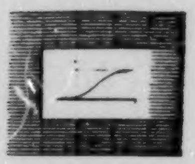
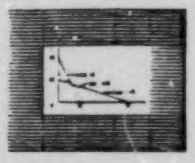
TABLE OF CONTENTS



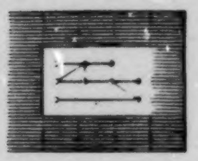
INTRODUCTION, I-1



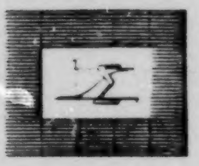
PUPIL PERFORMANCE AND FINANCIAL RESOURCE UTILIZATION MODEL, II-1



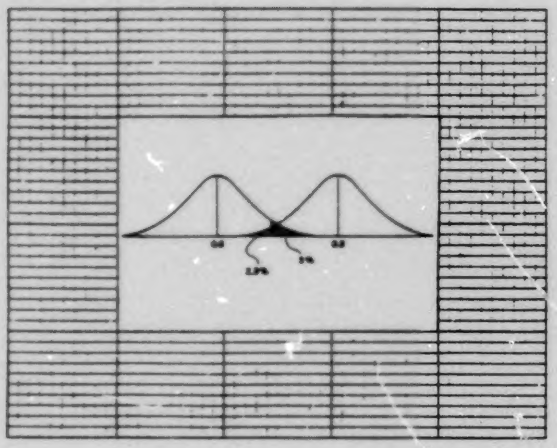
FINANCIAL RESOURCE ALLOCATION PROCEDURE FOR ACHIEVING PUPIL PERFORMANCE TARGETS: A GOAL PROGRAMMING APPROACH, III-1



THE OPERATIONAL STRUCTURE OF A SCHOOL SYSTEM AND PUPIL PERFORMANCE: A PUPIL FLOW MODEL, IV-1

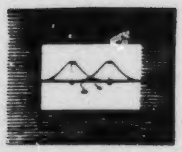


SUMMARY AND CONCLUSION, V-1



CHAPTER I.

INTRODUCTION



INTRODUCTION

Traditionally, free public education has been perceived as a social obligation whose aim is to equip children for their future roles as citizens in a democratic society and competitors in a market economy [see Peterson, 1973]. Granted this view, the legislators of the State of New York have used their prerogative and delegated the implementation of this obligation along with a significant portion of the financial means to local educational jurisdictions (school districts). Thus, public education is said to be a "publicly-induced collective good" because it is financed by one segment of society (taxpayer) and benefits another [see Fox, 1972; Cohn, 1975].* Recognizing that the educational resources available for pupils depends on whether they live in a property-rich or poor district, the legislators have attempted to minimize the "horizontal inequities" (between districts) by supplementing the budget of the districts through state aid [see Cubberly, 1905; Strayer Haig, 1923; Mort, 1933 and others, cited in Cohn, 1974]. Despite this legislative measure, some education finance problems still remain in the educational sector.

Until recently, inquiries concerning educational finance problems dealt with the problem of inequality of resource distribution, rather than with the amount of resource needed to realize some educational goals [see Cohn/Millman, 1975]. This inequity problem was examined by courts, commissions and researchers alike.

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*Authors cited henceforth are listed in alphabetical order in a bibliography at the end of this chapter.

While the issue of the establishment of standards for equal treatment of children was raised in certain court cases [see Serrano vs. Priest, 1976; Robinson vs. Cahill, 1973; Levittown vs. Nyquist, 1978; San Antonio vs. Rodriguez], the Commission's preoccupation was confined to the tasks of identifying perceived problems and suggesting some administrative remedies, to the equity problems [see Fleischman, et al., 1972; Gerber, et al., 1979; Rubin, et al., 1982]. Concurrently, researchers have investigated the inequity phenomena, and reported their findings in various documents [Bezeau, 1979; MacMahon, 1978; Johns, 1976].

Recently, researchers have broadened their inquiries and began to quantify the relationships between means (resources) and ends (pupil achievements) of the educational systems of the State of New York [see Heim, 1972; Wendling/Cohen, 1981; Spottheim-Libassi, Dec., 1982]. This effectiveness problem was analyzed through the application of an amalgamated approach which reconciles educational economic theories, econometric methods and the appropriate data.

Concurrently, interest has developed around the application of goal programming techniques (in conjunction with those models) to the problem of allocating needed resources to ascertain the desired level of pupil performance (Morgan, 1977; Spottheim/Wilson 1983). The rationale for applying this technique is based on the perception that school districts are "firms," operating in a "nonmarket economy," whose function is to render publicly-induced collective goods (Cohn 1975). Firms operating in a "market economy" must procure and allocate needed inputs efficiently, if they wish to produce certain levels of outputs and survive in this type of environment.

However, school districts possess "symbiotic" relationships between expenditures incurred and revenues received (from locally-imposed property taxes). As a result of such relationships (and in light of their operational environment), efficacious resource allocation methods were not fully utilized by the educational systems. Finally, the application of systems theory to the operational problems of the school systems was advocated recently in the literature (see Natale, Fall 1981).

Such inquiries have influenced the current research directions in the field of educational economics, whose prevailing inquiries tend to concentrate on predicaments such as:

- equity of taxation
- equity of fund distribution
- taxation efforts and state equalization policies
- cost of education indices
- resource allocation within school districts
- centralized finance and local control

While the field of educational economics is concerned with a variety of financial issues and predicaments, this report is confined to the analysis of the problems of:

- efficacious resource allocation within school districts
- efficacious pupil movement within the existing operational structure of a school system.

Although these problems could be examined from various disciplinary points of view, it was decided to use those (economics) theories and quantitative methods that were employed by investigators while analyzing analogous (or homologous) predicaments. These theories, however, were supplemented by concepts culled from related fields, and the methods were tempered with newly advocated biostatistical and management sciences concepts. In using this amalgamated approach, an array of administrative data were reduced to a manageable set of equations thereby gaining a better understanding of the educational phenomena in question.

Thus, the springboard for the methods used in Chapter II - The Pupil Performance and Resource Utilization Model are empirical studies portraying the quantitative relationships between educational means (resources) and ends (outcomes). The model presented in this chapter consists of 18 equations. Each of the equations shows the quantitative relationships between a particular educational outcome (end) and a set of expenditures (by educational function). An outcome is measured in terms of a probability that a school district will "produce" a predetermined educational outcome (i.e., probability that its pupils pass a given state administered test). The expenditures (per enrollee) are the explanatory variables (or education means) of the model. While these outcomes measure the so-called "higher order reasoning," they do not measure what the pupils "actually learned." However, it was decided to use these probabilities, inasmuch as measurable variables depicting the latter concept are not ubiquitously available.

In Chapter II a descriptive model protraying the relationships between educational means and ends is presented, whereas Chapter III deals with the application of a "prescriptive" method used in conjunction with that model. Specifically, Chapter III concerns itself with the application of goal programming techniques to the problem of efficacious resource allocation within the school districts so as to ascertain a desired level of achievement (outcomes or outputs). The resource allocation procedure presented in this chapter was realized through a belated but useful process of amalgamating econometric and operations research techniques.

Chapter IV, on the other hand, deals with the presentation of a model portraying the operational structure, processes and outcomes of a single school district. The units of analysis (cases) in this model are pupils, whereas the cases (observations) in the aforementioned models are school districts. The central theme behind this effort was the premise that the complex operational structure of a school system and its outcomes can be mathematically represented, through the application of a quantitative method called a "complex linear flow technique". The model was developed through a rapproachment of organizational theories and management science techniques. Finally, the conclusion of this endeavor is presented in Chapter V, and an abridged version of this report can be found in another paper.†

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†See Spottheim, D., et al "Public Education Resources and Pupil Performance Models; A Summary Report." LIRPB, Hauppauge, N.Y., August 1984.

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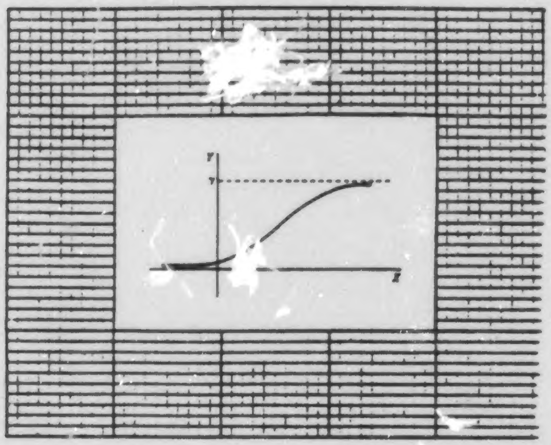

CHAPTER II.

PUPIL PERFORMANCE AND FINANCIAL RESOURCE UTILIZATION MODEL

PUPIL PERFORMANCE AND FINANCIAL RESOURCE UTILIZATION MODEL‡

I. INTRODUCTION

The increasing economic costs of public education have intensified the debate concerning the relationship between expenditures and the quality of education. Consequently, this debate has been transformed into a public demand for improved pupil performance through the adoption of more "effective teaching" and more efficient utilization of resources. (See for example B. Schorr in the W.S.J. Dec. 15, 1983.)* In earlier exploratory studies it was argued that such policies could not be implemented effectively because the prevailing accounting and recording practices barely lend themselves to the evaluation of the relationship between money spent (inputs) and results (outcomes) obtained (See Wohlfred 1970). Several empirical models which denote such relationships were developed recently (see Cohn 1975; Morgan 1977). However, these models are rarely used by educational institutions as tools to simulate or formulate financial policies, and this predicament can be attributed to factors such as:

- The prevailing notion that there is no relationship between resources used and pupil performance (see for example Newsday editorial Jan. 10, 1984).

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*Authors and sources cited henceforth can be found in the bibliography; they are listed in alphabetical order.

‡This chapter is an edited copy of an earlier Working Paper (No. 8) with the same title by Spottheim/Libassi (March 1984).

- The philosophical base (paradigm) of "Ed-psychometric" research.
- The symbiotic relationships that exist between revenue received and expenditure incurred by the school districts.

To support the first notion, educators tend to cite an earlier exploratory study and numerous unsuccessful attempts to construct equations (model) which portray linear relationships between educational means (resources) and outcomes (see Reed, N.Y. Times Nov. 13, 1984). This rationale, however, can be disputed because empirical models are seldom linear. Although a model may be deduced to be theoretically linear, its exact mathematical form can only be empirically determined through the application of quantitative methods (Hu 1973). This assertion was used recently as a guidance to construct a prototype nonlinear model composed of several "logistic" equations (see Spottheim/Libassi 1983), and the empirical model presented hereafter.

The lack of quantitative techniques application to the educational finance problems also could be attributed to the fact that educational research is dominated by the field of "Ed-psychometric." The examination of the interrelationships between psycho-educational variables in a controlled experiment is the focus of this field. Moreover, these studies have a tendency to be "Micro" in nature, and thus they have little policy implication. Econometric research, on the other hand, is a theory laden approach (Shapiro Feb. 1984). The aim of this approach is to draw inferences about the "population" from which the sample was drawn in light of a particular theory. Since an econometric approach is based on the premise that a socio-economic phenomena cannot be examined in a controlled environment, interrelationships (between variables) are specified according to prescribed theoretical concepts and the findings are validated by empirical tests concerning the deviation of the estimated (predicted) results from reality (Brennan 1965). Although both research approaches may share common techniques, they differ in their method of interpretation of findings. This difference can be understood in terms of the aims of these fields. The Ed-pschometricians' goal is to analyze and explain a phenomenon under investigation, whereas econometrians use quantitative methods (along with the appropriate data) to test a theory intended to be used for policy decisions (Shapiro, Feb. 1984). In other words, the analysis in the economic approach is not an end in itself, rather it is a means for testing and validating operational theories.

Finally, an assertion can be made that efficacious resource allocation methods are not fully utilized by educational systems because of the "symbiotic" relationship that exists between expenditure(s) incurred and revenue received. (Spottheim et al, June 1983). That is, the school districts as "municipal entities" possess the power of taxation to finance educational services. As such, they can be regarded as "firms" operating in a "non-market economy." Firms, operating in a "market economy," must procure and allocate needed inputs efficiently, if they wish to produce certain levels of outputs and to survive in a competitive environment. These firms are viable as long as their revenue is greater than their expenses. The districts, on the other hand, do not face such a challenge: they can always use the option of raising taxes, and/or requesting an increase in "state aid" for education.

Inadequate concern for inputs/outcomes relationships by the school districts is reflected in other fiscal decisions they make. In lieu of an operational model, school districts tend to rely on conventional means whenever they face public pressure to curtail expenditures. In response to such pressure, the districts tend to take actions such as:

- taxation limits (i.e., property tax rate limits)
- expenditure limits
- across the board cut of budget requests by various departments
- fund allocations which are based on thoughts concerning "educational minimum."

Such actions, however, seem to reflect the "intrinsic feeling and taste" of the involved parties, rather than systematic and comprehensive views regarding the operating system as a whole (Ackoff, 1972). Although they tend to be "remedial" responses to particular situations, these actions are vaguely "purposeful" inasmuch as they:

- barely address the issue of "societal and/or educational goals"
- disregard the effectiveness of various resources used by the system
- ignore the organizational structure of the educational system in question, the interdependency that exists among the components (entities) of that system and between these elements and the external socio-economic environment (adapted from Ackoff 1972; Fox 1972).

The empirical model presented in this paper was constructed with these issues in mind. It was calibrated through the application of educational economics theories in conjunction with complementing quantitative methods and appropriate data. These theories, however, were supplemented by concepts culled from related fields, and the methods were laced with newly advocated biostatistical concepts.

The idea behind the model is that several factors influence the educational outcomes. While many of these factors are under the control of the school districts, other factors (i.e., community characteristics) are beyond their control, and as such, these factors cannot be "manipulated" by the districts (see Fox 1972; Cohn 1975). These relationships were quantified through a belated but useful process of amalgamating biostatistical concepts, econometric techniques, and appropriate data. The current model can be expressed conceptually, as follows:

$$O_i = f(FRV_2, FRV_3, \ldots\ldots, FRV_K; TSCP_1, TSCP_2, \ldots\ldots, TSCP_L; COM_M; APNX_N)$$

where,

O_i = output measurement - or a dependent variable denoting the probability that a pupil will realize a particular level of performance while taking the i^{th} test.

FRV_k = input or financial expenditure variable under the control of the school district - an explanatory variable denoting expenditure by function (i.e., salaries, expenditures on equipment, material, contractual, BOCES)

$TSCP_1$ = teacher or school characteristic index - a nonfinancial explanatory variable

COM_m = community index measured (income or wealth) - an explanatory variable

$APNX_n$ = pupil performance index (in previous time period)- an explanatory variable

f = function symbol

The purpose of this paper is to inform interested audiences about the approach used to develop this model and to present its final statistical structure. This model was empirically constructed through the utilization of a data base containing 58 variables and 54 cases (e.g, school districts), in conjunction with a "maximum likelihood" method, at the SUNY at Stony Brook computer center. The model consists of 18 equations whose mathematical form is "logistic." Each of the equations shows the quantitative relationships between a particular educational outcome and a set of expenditures (by educational function). An output is measured in terms of a probability that a given school district will "produce" a particular educational outcome (i.e., its pupils pass a given state administered test). The expenditures per enrollee are the explanatory variables of the model. Finally, the model was designed for use in conjunction with an "operations research" technique in order to determine the composition of resources required to achieve predetermined and/or desired educational outcomes.

While this expository paper is addressed to an audience composed of educators, researchers, and administrators who have some knowledge of the methodology, professional jargon was kept to a minimum. Thus, the remainder of this paper is structured as follows: Section II contains a brief review of the literature, whereas the conceptual model is presented in Section III. In Section IV the calibration results and the empirical model are presented. Finally, the summary and conclusion of this endeavor is presented in Section V.

II. REVIEW OF THE LITERATURE

The construction of the empirical model was realized through the application of accepted theories and quantitative techniques found in the literature of several fields. Hence, this section emphasizes topics such as: educational resource allocation methods, educational production functions and a discussion of recent and relevant biostatistical concepts.

A. Education Resource Allocation Methods

Although a lively debate about quality, effectiveness, and the cost of education is in progress in the news media (the Wall Street Journal, Dec. 23, 1982; the Washington Post, July 18, 1983, July 19, 1983), these issues are by no means new. Rather they were examined quantitatively and documented in the literature. Commencing with a landmark study by Coleman (1966) through several studies in N.Y. State by Heim (1972), Wendling (1982) and Spottheim/Libassi (1982), educational inputs/outcomes relationships have been examined and analyzed from various points of view (disciplines). In the course of examining such relationships, researchers have employed various techniques (Morgan 1977), such as:

- Cost Benefit Analysis
- Planning Programming-Budgeting Systems (PPBS)
- Cost-Effectiveness Analysis
- Single and Simultaneous Production Function Equation(s)
- Linear Programming
- Goal Programming

While the cost benefit analysis technique was used to evaluate educational programs monetarily, the method was found to have fundamental problems inasmuch as the benefit of education is not easily measured (Welty 1971). PPBS techniques, on the other hand, have been used to identify and suspend educational programs which could not be justified in terms of both current demand and available resources (Hill, 1963). Cost effectiveness analyses techniques have been used to overcome the difficulties associated with cost benefit analysis. According to Cohn (1972), this method is a useful tool for examining a situation where an administrator must choose between two educational methods; a capital intensive and a labor intensive approach of teaching.

The educational production function approach is a method which has been used to establish the relationship between educational inputs used and outputs produced. Unlike cost benefit analysis which calls for indices denoting the educational benefits, this technique requires only information concerning inputs (resources or means) and outputs of the educational system. Investigators, who used this approach, have perceived the schools to be analogous to "firms." According to Morgan (1977), the first researcher to employ this approach was Thomas (1962), followed by a study by Coleman (1966). Other models were developed by Cohn (1968), Cohn and Milman (1975), Bieker (1973), Heim (1972) and Wendling (1980), who have used nonfinancial variables as explanatory variables while constructing linear models. Chang (1980) constructed a classical production function formula to derive cost and expenditure indices for the school districts of the State of Virginia. Spottheim and Libassi (1982) have developed a prototype log-logistic model whose explanatory variables consist of various expenditures per enrollee incurred by the school districts.

Recently, educational production function models were used in conjunction with linear-goal programming techniques to allocate resources to ascertain predetermined educational objectives. Cohn (1977) and Morgan (1977),for example, have applied production function equations in conjunction with a linear goal programming technique to the problem of resource allocation within a school district; while Adelman (1966) has employed linear programming to allocate resources for the Argentine's educational sector. Spottheim and Wilson (1983) have used a non-linear goal programming technique in conjunction with the aforementioned prototype model.

The goal programming method presupposes that school administrators can hierarchically rank specific educational outcomes (or targets). Unlike linear programming, this technique searches for a "satisficing" (rather than optimizing) solution concerning the mix of required resources to realize the desired educational goals or outcomes. That is, if an exact resource (inputs) mix is impossible to obtain, this method would provide a solution which minimizes the sum of the deviations from the prespecified educational targets. It would also determine the amount and mix of resources needed to ascertain these prioritized targets (Ignizio 1982).

B. The Educational Production Function Models

The production function as was noted earlier is a formula portraying the inputs (resources) and outputs (product) relationships and as such it plays a major role in the theory of the firm (Douglas 1928). This formula also can be graphically transformed into a cost curve. Traditionally the inputs (or production factors) of this formula are denoted by labor and capital variables, whereas the output variable was denoted by a production index. Since the coefficients associated with the input variables of the traditional formula are exponential, they are said to be "elasticity" measurements. In other words, they denote the percentage change of the output associated with one percent change in a particular input. Consequently, these functions were applied to simulate the relationships between varying amounts of input(s) used and the quantity of commodity (product) that could be produced.

As noted earlier, this concept has been applied to estimate the input/output relationships in the public educational system. Such a function, however, is more complicated than the traditional one, because the schools produce multiple outputs and employ a complex of inputs to produce these outputs (Cohn 1975). Heim (1972) and Wendling (1981), for example, have shown such relationships while using N.Y.S. Education Department data. These authors (like their predecessors) have used reading and math achievement scores (of elementary school pupils) as surrogate for pupil performance (i.e., school outputs). They have estimated linear relationships between these scores and resources (i.e., input), such as:

- teacher experience
- teacher educational level
- pupil/teacher ratio
- school size
- operating budget
- instructional expenditure
- educational level of adult population residing in the districts
- poverty/income level (Heim, 1972; Wendling, 1981)

Cohn & Millman (1975) have developed an educational production function model composed of a system of simultaneous (semi-endogenous) equations. The explanatory variables of their model are similar to those used by Heim (1972). However, unlike Heim's model, their study is based on the premise that the output variables are "jointly dependent."

While the Heim, Cohn and Wendling models are based on the premise that the outputs of the schools can be explained (and estimated) in terms of qualitative measurements denoting teachers, school, socioeconomic and pupil attributes, the premise behind this effort is that similar (but not identical) outputs could also be explained in terms of financial information concerning expenditures on: salary by type; supply/material/equipment; contractual; as well as income and/or property wealth of the districts. The current effort, however, required the incorporation of newly developed statistical concepts into the methodology because it is not a direct extension of models just discussed.

C. Statistical Considerations

The recently developed "educational input/output" models are composed of a static and "semi-endogenous" system of linear equations, because the outcome variables are said to be "jointly dependent" (Cohn 1975) In other words, an output variable can appear as a "dependent" variable in one equation and enter into a successive equation as an "endogenous explanatory" variable (see Spottheim 1980, 1983). Biostatisticians dubbed such models: as a "causal linked nonrecursive system of equations" (Fienberg 1980). However, it is stated in the literature that a nonrecursive systems of logistic (logit) equations (whose properties "mimic" a semi-endogenous system of linear equations) should not be calibrated (Fienberg 1980). The rationale behind this statement is that the dependent variable (which is a probability measurement) cannot be used concurrently as a "response" and explanatory variable (Brier 1978, cited in Fienberg 1980). Although Heckman (1977) has developed a computational procedure for a simultaneous system, his procedure is applicable to a "probit," rather than a logistic (logit) model (see Heckman, cited in Fienberg 1980). Thus, his approach was not considered for this endeavor.

Because of this methodological assertion, the continuation of an earlier effort (to construct a static nonrecursive system of logistic equations) was aborted (see Spottheim-Libassi 1982). Thus, the model presented henceforth can be dubbed as a "prospective" logistic equations model. Moreover, unlike the previous model (Spottheim-Libassi 1982) the explanatory variables in the current model are linear (instead of log). This approach was taken so as to allow us to use this model in conjunction with a linear goal programming technique.

In sum, the econometric techniques used to construct the model were laced with newly-developed statistical concepts. Such tempering was necessary because the conceptual view of the system, the theoretical model and the nature of the data base, called for the construction of a model whose form is analogous to "dose response" models found in biostatistical and epidmiological studies. Traditionally, these kind of models are composed of a single equation and these probalistic models are used to assess the effect of categorical (dose) variables upon a "response" variable (Goldstein 1964) whereas our model contains 18 equations whose dependent variables are the natural log of "transformed" probability variables and the explanatory variables are linear.

III. THE CONCEPTUAL MODEL

It has been asserted in the literature that the process of decision-making should be supplemented by empirical models as tools, for simulating the impact of alternative policies upon the operation of the system in question (Ignizio 1982). Commonly, such models are based on a conceptualized view concerning the recurrent and anticipated "behavior", processes, and outcomes of the system. Considering the foregoing view as a "given", the presentation that follows contains a conceptual overview of the educational system on Long Island. A narrative concerning the educational input/output (outcome) relationship is then presented. Finally, this conceptual overview is portrayed formally, inasmuch as the propositions embedded in it imply some mathematical relationships.

A. An Overview of the Educational System

While free education is considered to be a state obligation, the legislators of the State of New York have used their prerogative and delegated the implementation of this obligation along with a significant portion of the financial means to local educational jurisdictions (Fleischman 1972, Rubin 1982). Thus, the school districts are said to be "municipal jurisdictions" whose single responsibility is to deliver free education to their children. To finance such services, the districts possess the power of raising the necessary revenue through real property taxes. In other words, the educational services rendered by the district(s) are "publicly-induced collective goods" inasmuch as they are financed by one segment of society (taxpayer) and benefit another (Fox 1972). The observed symbiotic relationship between taxation and expenditure(s) has led to a situation whereby the districts exhibit a decision-making pattern similar to firms which operate in a "non-market environment" (Fox 1972). Characteristic of this situation is that although the districts produce multiple outputs (outcomes or "products") and use a variety of resources, their decision-making environment is periodically subject to conflicting interests, policies and opinions. Consequently, remedies for controversial predicaments (concerning resources and outcomes) tend to be antidoctal in nature suited for a particular occasion. In fact, such solutions could hardly be substantiated theoretically inasmuch as they are "a compromise" of a collection of "intrinsic opinions" reflecting the concerned parties' taste and style regarding educational input/outcomes relationships (Cohn 1980). Observing this decision-making environment led us to believe that the situation could be mitigated by providing the decision makers with a model portraying the input/outcome relationships. The idea behind such a model is that it could be used as a "benchmark" by these parties to:

- understand and clarify the predicaments in question
- complement the judgement process
- improve the decision-making process (see Ignizio 1982)

B. The Input/Output Relationships

The provision of educational services (by the districts) was essentially observed to be a set of actions (educational and administrative) taken in relation to pupils with the intention of assisting them to accumulate the knowledge and skill necessary to function as citizens in a contemporary society and this observation complements an earlier court decision in the N. J. case of Robinson vs. Cahill. (see Robinson vs. Cahill cited in Peterson 1973).

In transforming the "status" of the pupils through the application of "educational processes," the districts generate multiple outputs (educational ends or outcomes), while using multiple types of resources or means (manpower, material, equipment, and finance) to produce the outcomes (see Fox 1972; Cohn, Millman 1975). The educational processes, therefore, are said to be analogous to processes employed by other "human processing organizations," (see Hasenfeld 1972; Spottheim 1975). The multiple educational ends (i.e., outcomes or outputs) of the Long Island districts are said to be the probability[1] of school districts whose pupils:

- scored above state reference point (SRP) in selected 3rd and 6th grades proficiency exams administered by the State of New York
- scored above SRP in selected Regents competency tests (RCT) for grades 9-11
- passed selected Regents graduation requirement tests
- graduated high school and left for a 4-year college
- graduated high school and left for a 2-year college and other institutions
- graduated high school and left for employment, military service and other destinations
- dropped out of school

---

[1] These educational and variables were found to be the most appropriate, given the type of information available.

To generate these ends (outputs), school districts are said to employ financial and manpower resources as inputs. Such inputs can be denoted by per-pupil expenditure on:

- instructional salaries
- non-instructional salaries
- equipment, supply, material and textbooks
- contractual, BOCES,[2] and other categorical services and programs.

Additionally, community attributes (resources beyond the control of the school district) also influence the educational outcomes. Thus, it was hypothesized that a variable denoting the district "wealth" (income net worth) can be used as surrogate depicting the community contribution (inputs) to the educational process.

Finally, non-financial variables were also said to influence the outcomes. Thus, it was hypothesized that indices denoting teachers and school attributes will influence the outcomes. These outcomes, however, are said to be tempered by (qualitative) indices denoting pupil performance (or "quality" of pupils) in a previous year. Non-financial indices depict the following attributes:

- number of book titles in the school library
- school district size
- crowdedness (Sq./ft. per pupil)
- teacher's qualification/experience
- pupil quality or previous year performance

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[2] BOCES is an acronym for "Board of Cooperative Educational Services," whose services are used by the school districts on a contractual basis.

C. The Theoretical Model

The preceding narrative concerning the structure and behavior of the educational jurisdictions can be expressed (symbolically) in a mathematical form. Such an expression can then be used as the theoretical model, and consequently it could be calibrated and empirically tested. A mathematical expression has other advantages, such as:

- explicitly illuminates the assumptions and definitions mentioned in the narrative
- rigorously defines relationships
- avoids the digression of vague arguments
- illuminates the shortcomings of the approach (Brennan 1965)

This argument about research methods was used as a guide while specifying the theoretical model. The advantage of this approach (in our instance) is that it also summarizes the conceptual overview of the system, statistical concepts along with relevant theories, and an array of administrative data into a manageable theoretical equation.

Recall that the theoretical model was hypothesized to have a logistic (logit) structure, showing the relationships between the probability of achieving a certain outcome (by pupil enrolled in a given district) and the corresponding expenditures (per pupil) incurred by that district. Similarly, it is analogous to an epidemiological model because the outcome and expenditures are analogously related to the concepts of "response" and "dose" (or stimulus) respectively. Since the probable outcome "i" (for school districts "j") in this model is said to be influenced by a set of expenditures ($FRV_{k,j}$) and other attributes ($TSCP_{l,j}$; $COM_{m,j}$; $APNX_{n,j}$), the theoretical model can be expressed in the following mathematical form:

$$1.\quad O_{i,j} = 1/1+e^{-a_i - \sum_{k=2}^{K} b_k FRV_{k,j} - \sum_{l=1}^{L} c_l TSCP_{l,j} - \sum_{m=1}^{M} d_m COM_{m,j} - \sum_{n=1}^{N} e_n APNX_{n,j} - U_{i,j}}$$

Where;

$O_{i,j}$ = dependent variable (to be forecasted) denoting the probability that an outcome "i" will be realized at a particular school district "j"

$FRV_{k,j}$ = input or financial expenditure variable under the control of the school district - an explanatory variable denoting expenditure (per pupil) by function "k" (i.e., salaries, expenditures on equipment, material, contractual, BOCES) of school district "j"

$TSCP_{l,j}$ = teacher or school characteristic index "l" - a nonfinancial explanatory variable observed in school district "j"

$COM_{m,j}$ = community index "m" - an explanatory variable denoting the socio-economic condition of school district "j"

$APNX_{n,j}$ = pupil performance index "n" (previous time period) observed in school district "j" - an explanatory variable

e = 2.71828. . . . . . .

a_i, b_k, c_l, d_m, e_n = parameters (coefficients) associated with their respective explanatory variables - their values could be determined (or calibrated) empirically.

Σ = summation symbol

$U_{i,j}$ = a residual (or error term) associated with the outcome "i" and school district "j"

The probability variable O_{ij} was derived through the aggregation of a dichotomous variable "Y_{ij}", (denoting whether a pupil enrolled in school district "j" passed (or failed) state administrated test "i") and dividing this sum by the total no. of pupils (of that district) who took the test.**

In sum, the model presented above is not a direct extension of the previously reviewed studies. Rather, it is based on a hybrid of

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**The value of O_{ij} for the various districts was derived as follows:

$$O_{ij} = \sum_{i=1}^{N} Y_{ij}/N_{ij}$$

Where;

Y_{ij} = 1, if a pupil enrolled in school district "j" passed the test "i", above SRP; otherwise Y_{ij} = 0

N_i = Total no. of pupils enrolled in school district "j" who took the "i^th^" test.

theoretical concepts culled from an accepted body of economic and biostatistic theories. Specifically, the theory of "non-market economics" (Fox 1972) in general, and "educational production function" concepts (Coleman 1966, Cohn 1975; Heim 1972) in particular, along with biostatistical concepts (Colquohoun 1971; Fienberg 1980): all are embedded in this model. This theoretical equation was used as a "benchmark" while specifying the calibration and validation procedure for the 18 equations of the model.

IV. CALIBRATION AND VALIDATION

To construct the data base for this endeavor, some 150 school finance and accounting items along with a score of pupil performance indicators and dozens of non-financial indices were culled from eclectic administrative sources for 72 school districts located in Long Island, N.Y. This "raw" data base[3] was then analyzed through the application of multivariate statistical methods (i.e., factor analysis) and aggregated into a set containing some 100 variables.[4] Consequently, a matrix containing 54 cases (school districts)[5] and 58 variables[6] was constructed as the data base of the model. The variables of this data base are defined below in Table I. While these definitions are self contained, several of them are explained below.

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[3] A list of these variables can be found in Appendix A of this paper.

[4] A list of this set of variables can be found in Appendix B of this paper.

[5] Note only those educational jurisdictions (districts) which are composed of both elementary and high schools were used as cases to construct the model empirically. The excluded 18 cases are composed of small elementary school districts.

[6] A list of these variables can be found in Appendix C of this paper.

TABLE I

LIST OF VARIABLES USED TO CONSTRUCT THE MODEL

I. RAW DEPENDENT VARIABLES

A. Exam Results (Elementary School); Probability Measurements

Var. No.	
O_1	Reading Exam 3rd Grade - Above State Reference Point (SRP)
O_2	Math " " " " " " "
O_3	Reading Exam 6th Grade - " " " "
O_4	Math " " " " " " "

B. RCT Exam Results (Sec. Schools); Probability Measurements

O_5	Math Exam 9th Grade - Above SRP
O_6	" " 10th " " "
O_7	" " 11th " " "
O_8	Reading " " " " "
O_9	Writing " " " " "

C. Regents Graduation Exams; Probability Measurements

O_{10}	Regents English Exam - Above SRP
O_{11}	" Math 10 " " "
O_{12}	" Biology " " "
O_{13}	" Chemistry " " "
O_{14}	" Social Studies " "

D. Destination of High School Graduates: Probability Measurements

O_{15}	Post Secondary 4 Years College
O_{16}	Post Secondary 2 Years College
O_{17}	Employment/Military
O_{18}	Dropout
O_{19}	Other

II. TRANSFORMED DEPENDENT VARIABLES (LOGIT)

A. Exam Results (Elementary School)

Q_1	Reading Exam 3rd Grade - Above State Reference Point (SRP)	$\ln O(1)/[1-O(1)]$**
Q_2	Math " " " " " " "	$\ln O(2)/[1-O(2)]$
Q_3	Reading " 6th " " " " "	$\ln O(3)/[1-O(3)]$
Q_4	Math " " " " " " "	$\ln O(4)/[1-O(4)]$

B. RCT Exam Results (Sec. Schools)

Q_5	Math Exam 9th Grade - Above SRP	$\ln O(5)/[1-O(5)]$
Q_6	" " 10th " " "	$\ln O(6)/[1-O(6)]$
Q_7	" " 11th " " "	$\ln O(7)/[1-O(7)]$
Q_8	Reading " " " " "	$\ln O(8)/[1-O(8)]$
Q_9	Writing " " " " "	$\ln O(9)/[1-O(9)]$

**ln = A symbol denoting natural log.

C. Regents Graduation Exams

Q_{10}	Regents English Exam - Above SRP	$\ln 0(10)/[1-0(10)]$
Q_{11}	" Math 10 " " "	$\ln 0(11)/[1-0(11)]$
Q_{12}	" Biology " " "	$\ln 0(12)/[1-0(12)]$
Q_{13}	" Chemistry " " "	$\ln 0(13)/]1-0(13)]$
Q_{14}	" Social Studies " " "	$\ln 0(14)/[1-0(14)]$

D. Destination of High School Graduates

Q_{15}	Post Secondary 4 Years College	$\ln 0(15)/[1-0(15)]$
Q_{16}	Post Secondary 2 Years College	$\ln 0(16)/[1-0(16)]$
Q_{17}	Employment/Military	$\ln 0(17)/[1-0(17)]$
Q_{18}	Dropout	$\ln 0(18)/[1-0(18)]$

III. EXPLANATORY, FINANCIAL RESOURCE AND OTHER INPUT VARIABLES

A. Financial Resource Variables (Measured in dollar per pupil unit)

Var. No.	Var. Code	
X(1)	FRV2	Instructional Salaries - Chief School Admin.
X(2)	FRV3	Instructional Salaries - Admin., Improvmnt. & Planning
X(3)	FRV4	Instructional Salaries of Teachers K-6 per grade K-6 enrollment
X(4)	FRV5	Instructional Salaries - Teachers 7-12 per grade 7-12 enrollment
X(5)	FRV7	Total Expenditure for PSEN per PSEN Pupil†
X(6)	FRV10	Instructional Salaries - Pupil Health, Psych. Soc. Ser.
X(7)	FRV12	Total Interscholastic Athletics
X(8)	FRV14	Community/Youth Service-Instructional Salaries
X(9)	FRV19	Average Teacher Salary Total (K-12) (Not per pupil unit)
X(10)	FRV20	Other Instructional Expenditures (i.e. substitute teachers)
X(11)	FRV21	School Library Total
X(12)	FRV22	Computer Service/Ed. TV Total
X(13)	FRV24	Co-Curricular Total
X(14)	FRV25	General Support & Empl Benefit (overhead)
X(15)	FRV26	Pupil Transport. & Maintain. Total (overhead)
		BOCES
X(16)	FRV27	BOCES-Adm/Plan/Improvement Expenditure
X(17)	FRV28	BOCES-Inst. Teaching
X(18)	FRV29	BOCES-Pupil & Comm. Services
		CONTRACTUAL (& TUITION)
X(19)	FRV31	Contractual-Adm/Plan/Improvement
X(20)	FRV32	Contractual-Inst. Teaching and Tuition
X(21)	FRV33	Contractual-Pupil & Comm. Services
		BOCES & CONTRACTUAL
X(22)	FRV36	Instructional-BOCES & Contractual (FRV28 + FRV32)

SUPPLY MATERIAL, TEXTBOOK & EQUIPMENT

X(23)	FRV47	Admin/Plan/Improvement (FRV39 + FRV43)
X(24)	FRV48	Instructional teaching (FRV40 + FRV44)
X(25)	FRV49	Pupil and Community Services (FRV41 + FRV45)

NON-INSTRUCTIONAL SALARIES

X(26)	FRV51	Non-Inst. Sal.-Adm/Pln/Improvement/Teaching
X(27)	FRV52	Non-Inst. Sal.-Pupil & Comm. Services

B. Teacher/School, Community and Pupil Attributes Indices

X(28)	TSCP1	No. of Book-Titles in the Library
X(29)	TSCP2	School Size Index (1 if more than 4800 pupils; 0 Otherwise)
X(30)	TSCP7	Sq./ft. of Class Room per Pupil-a crowdedness index
X(31)	TSCP8	School Teacher Characteristics Index
X(32)	COM2	Income per Return - denotes community attributes
X(33)	COM3	Community Wealth Index

C. Pupil Characteristics Previous Year

X(34)	APNX1	3rd grade pupil perf. index time "t-1"++
X(35)	APNX2	6th grade " " " " "
X(36)	APNX3	9th grade math RCT " " "
X(37)	APNX4	10th grade math RCT " " "
X(38)	APNX7	Regents English " " "
X(39)	APNX8	Regents Math 10 " " "
X(40)	APNX9	Regents Biology " " "

+PSEN is an acronym for pupils with special educational needs.

++ Note $APNX_i$ are binary (dummy) variables.

A. The Nature of the Data Base

A cursory examination of Table I reveals that the data base is composed of measurements concerning the probable pupil performances (by districts), financial variables (FRV's), teacher/school attributes, community characteristics and pupil quality indices. The former are variables denoting the probable outcomes (by districts), rather than quantitative variables, while the financial variables depict:

- in-house expenditures (per enrollee) on services such as:
  - instructional salaries - teaching
  - instructional salaries - administration/planning/improvement
  - pupil (health, psych. and social services) and community services
- expenditures incurred by districts for same type of services rendered by (contractual) vendors (i.e., BOCES)
- expenditures on supply/material/textbooks
- expenditures on co-curricular activities
- expenditures on athletics
- expenditures on administrative (i.e., employee benefits) and operational (i.e., pupil trans. and facility maintain) overheads
- expenditures on non-instructional salaries

The premise behind these aggregated variables is that they represent a special case of "factors of production." The sum of these financial variables virtually cover the entire "approved operational budget" (per pupil) of the district.[7] In addition to the above non-financial variables were also used to construct the model.

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[7] Average teacher salary is not part of this budget. It merely reflects the average salaries by districts.

The teachers/school attributes are denoted by a set of (non-financial) indices. They are said to be "qualitative" factors of production which are likely to influence the (probable) outcomes (or outputs) of the districts (see Coleman 1966; Heim 1972; Cohn 1975). For instance, the teacher qualification index (TSCP8) is a compounded measurement, reflecting the average years of teacher education (i.e., high school, BA, MA, PhD), experience and certification (to teach one or more subjects) by school district.

Community attributes are said to influence the school outcomes even though they are beyond the control of the school districts. As such, they cannot be "manipulated" by the system (Cohn 1975). While non-financial measurements could have been used as "proxy" for these attributes, it was decided to measure them in monetary terms. Multivariate statistical analysis reinforced this decision because this analysis revealed a high correlation (negative) between the financially measured community variables and indices such as:

- % of pupils failed in two or more subjects
- % of pupils with limited English language
- average teacher absence
- value of privately owned property in the district; a "poverty" proxy.

Thus, the average "income per (tax) return" (by school districts) was used as a "proxy" for the district's average income per household (COM_2), whereas a community "wealth" (net worth) index was used as an alternative variable (COM_3). The latter is a compounded variable which takes into account the value of privately-owned real property, current income and anticipated lifetime earnings of households residing in a district. In this instance, the districts wealth index is based on MacMahon (1980). It is discussed in detail elsewhere (Spottheim, Jan. 1983, Oct. 1983), and summarized below;

2. $WLTINX_{i,t} = WLT_{i,t}/Enrollment$

Wealth (WLT) was imputed as follows:

3. $WLT_{i,t} = Y_{i,t} + Y^*_{i,t} + \frac{1}{2}A_{i,t}$

Where;

$Y_{i,t}$ = current personal income total for district "i" at time "t" - could be derived from state income tax return

$Y^*_{i,t}$ = the present value of expected future income of district "i" at time "t"

$\frac{1}{2}A_{i,t}$ = asset or half of full market value of property only at district "i" at time "t" (privately owned dwelling units)

Notice the asset ($1/2A_{i,t}$) is defined above as half of the market value of residential property. The rationale for this variable is that throughout the lifespan of the mortgage, the homesteaders own (on the average) only half of their property. The present value of expected future income ($Y^*_{i,t}$) and its relation to current income was derived as follows:

4. $Y^*_{i,t} = bY_{i,t}$

where b - is a ratio of present value of expected lifetime earnings - its value by age and education was imputed from census tables, as was suggested by Miller and Hornseth (1967). This ratio is estimated so as to reflect the present value of lifetime earnings less the maintenance cost of the wage-earner(s) and their dependents. The maintenance cost is assumed to be about 40-45% of the estimated 1980 annual income of the districts. The value of "b" for each district is enumerated in a table in an earlier working paper (Spottheim, Jan. 1983).

Finally, the pupil "quality" measurements are binary (dummy) variables denoting whether the pupils (enrolled in a given school district) performed above or below the regional average (with respect to selected tests) in a previous year. As was noted above, these variables were hypothesized to reflect the quality of the "raw material" whose "status" (knowledge and skill) is to be "enhanced" through the utilization of the above mentioned factors of production (see Spottheim 1975).

B. The Hypothesized Structure of the Empirical Model

The aforementioned theoretical model (equation No. 1) was used as a conceptual "benchmark" while specifying the hypothesized structure of the model. It consists of 18 equations whose structure is presented pictorially in Chart I below. This chart contains 40 columns and 18 rows. The former are denoted by the explanatory variable codes, while the rows depict the various equations. An asterisk (*) in this chart denotes the explanatory variable hypothesized to be included in a particular equation.[8]

A cursory examination of the chart will show,for example, that the outcome concerning reading exam 3rd grade is said to be influenced by the following explanatory variables:

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[8] Parties interested in such a list are referred to Appendix D of this paper.

CHART I

A Pictorial Representation of the Hypothesized Model

EXPLANATORY VARIABLE INCLUDED

DEFINITION OF DEPENDENT VARIABLES		21 FRV2 X(1)	22 FRV3 X(2)	23 FRV4 X(3)	24 FRV5 X(4)	26 FRV7 X(5)	29 FRV10 X(6)	31 FRV12 X(7)	33 FRV14 X(8)	38 FRV19 X(9)	39 FRV20 X(10)	40 FRV21 X(11)	41 FRV22 X(12)	43 FRV24 X(13)	44 FRV25 X(14)	45 FRV26 X(15)	46 FRV27 X(16)	47 FRV28 X(17)	48 FRV29 X(18)	50 FRV31 X(19)	51 FRV32 X(20)	52 FRV33 X(21)	55 FRV36 X(22)	66 FRV47 X(23)	67 FRV48 X(24)	68 FRV[illegible] X(25)	70 FRV51 X(26)	71 FRV52 X(27)	73 TSCP1 X(28)	74 TSCP2 X(29)	79 TSCP7 X(30)	80 TSCP8 X(31)	82 COM2 X(32)	83 COM3 X(33)	90 APNX1 X(34)	91 APNX2 X(35)	92 APNX3 X(36)	93 APNX4 X(37)	96 APNX7 X(38)	97 APNX8 X(39)	98 APNX9 X(40)
Reading Exam 3rd Grade - Above SRP	Q_1	•	•	•							•		•	•			•								•			•	•												
Math Exam 3rd Grade - Above SRP	Q_2	•	•	•							•		•	•			•													•					•						
Reading Exam 6th Grade - Above SRP	Q_3								•	•				•				•									•									•					
Math Exam 6th Grade - Above SRP	Q_4		•	•										•				•			•								•	•						•					
Math Exam 9th Grade - Above SRP	Q_5				•	•														•	•										•			•			•				
Math Exam 10th Grade - Above SRP	Q_6									•	•					•					•			•				•				•									
Math Exam 11th Grade - Above SRP	Q_7	•	•																•						•						•										
Reading Exam 11th Grade - Above SRP	Q_8				•					•															•			•		•	•			•							
Writing Exam 11th Grade - Above SRP	Q_9	•			•		•								•			•				•					•														
Regents English Exam - Above SRP	Q_{10}				•						•				•				•			•																	•		
Regents Math 10 Exam - Above SRP	Q_{11}				•					•	•										•								•									•			
Regents Biology Exam - Above SRP	Q_{12}				•						•	•																						•							•
Regents Chemistry Exam - Above SRP	Q_{13}	•			•					•	•											•				•				•	•										
Regents Social Studies Exam - Above SRP	Q_{14}				•	•				•	•				•							•		•	•		•			•									•		
Post Secondary 4 Years College	Q_{15}		•		•		•	•						•				•							•									•							
Post Secondary 2 Years College	Q_{16}				•				•		•													•		•						•		•						•	
Employment/Military	Q_{17}		•											•				•							•							•	•								
Dropout	Q_{18}	•							•	•				•									•																•		

LEGEND

* = Hypothesized explanatory variable to be included in the equation

Q_1 = Equation no. and symbolic representation of a transformed dependent variable O_1

FRV, TSCP, COM, APNX = Code of explanatory variable.

X(i) = Sequence no. of explanatory variable.

X(1) FRV2 - Inst. salaries - chief school adm.

X(2) FRV3 - Inst. salaries - adm./improvement/planning

X(3) FRV4 - Inst. salaries - teachers K-6

X(10) FRV20 - Other instructional salaries (i.e., substitute teachers)

X(12) FRV22 - Computer and Ed. TV service

X(13) FRV24 - Cocurricular activities

X(16) FRV27 - BOCES adm./planning/improvement

X(24) FRV48 - Supply/material/books -teaching

X(27) FRV52 - Noninstructional salaries for pupil and community services

X(28) TSCP1 - No. of book titles in library

C. Mathematical Forms and Transformation

Recall, that the "hypothesized equations" were specified in a form which "mimic" the theoretical model (equation 1). This form, however, does not lend itself to the application of a calibration method. While the literature contains a variety of mathematical procedures that can be used for this purpose, it was decided to exclude all but one procedure.

For example, the use of a "linear probability function" was precluded because this form is known to generate "biased and inconsistent" results (see Zeliner and Lee 1963). The traditional "direct assays" form (used in biological studies) was found to be inappropriate because it calls for specification of both dependent and explanatory variables as log (to base 10) variables (see Colquhoun 1971). Such a specification also may hinder the application of the model in conjunction with the aforementioned linear goal programming technique.

Therefore, the "hypothesized equations" of the model were "transformed" into a "logistic function," thereby allowing us to estimate the coefficients via a regression technique. Following the Chiswick (1975) and Theil (1971) suggestion, it can be shown that upon "transforming" these equations, they will have the same structure as the (transformed) theoretical model, shown below:

$$5.\quad Q_{ij} = ln(O_{ij}/1-O_{ij}) = a_i + \sum_{k=1}^{K} b_k FMV_{k,j} + \sum_{l=1}^{L} c_l TSCP_{l,j} + \sum_{m=1}^{M} d_m COM_{m,j} + \sum_{n=1}^{N} e_n LJMK_{n,j} + \hat{U}_{i,j}$$

Where;

Q_{ij} = transformed dependent variable concerning the "i^{th}" outcome and "j^{th}" school

ln = natural log symbol

All other variables and parameters were defined earlier (see Eq. No. 1).

Notice that the left hand side of the above equation is analogous to the dependent variable in a multiple linear equation model. These transformed equations lend themselves to the application of a regression technique for the purpose of estimating the unknown value of the coefficients.

D. Calibration Methods

The calibration task can be defined as an effort to produce quantitative relationships between a probable educational outcome and a set of nonstochastic explanatory variables. The equations produced by this effort could then be used to draw policy-oriented inferences concerning the input/output relationship of the system. These equations also could be in conjunction with a "goal programming," as was suggested by Fox (1972) and by Cohn (1975) demonstrated by Cohn and Morgan (1977) and Morgan (1977).

To realize this empirical aim, alternative calibration procedures were examined. For example, the 18 logistic function (transformed) equations could have been only calibrated via a "Weighted Least Squares (WLS) method. A computer package for this method, however, was not available. Instead a "maximum likelihood" (ML) technique was used to estimate the final value of the coefficients. However, other measures were taken to handle computational problems.

The disadvantage of this ML method is that the coefficients are estimated through a complex calculation procedure and a tedious iteration process (Kmenta 1971). The ML computer program (used to calibrate the model) calls for a prior knowledge concerning the "initial approximated value" of the coefficients. To overcome these problems, the coefficients (associated with the explanatory variables) of the (transformed) model were initially estimated via an OLS method. Consequently, these coefficients were entered into the maximum likelihood computer program as "initial value" coefficients and the transformed model (i.e., 18 equations) was recalibrated again, via the ML technique, as was indicated in the manual of this technique (TSP-Wisc. 1980). In using this approach an empirical model containing "consistent" and "efficient" coefficients was obtained as was suggested by Kmenta (1971).

E. The Empirical Model and Calibration Results

The "hypothetized model" was pictorially presented earlier (see Chart I), whereas its empirical counterpart is presented formally (mathematically) in Table II. It contains a set of 18 "transformed" equations which were calibrated empirically via a ML technique.

To allow the interested reader to draw inferences concerning the "goodness" of the model, the 18 equations, along with additional information, are provided in the table that follows. Thus, the coefficients and their respective variables, the "standard error of these coefficients" (SEC) along with their corresponding "student-t" values, as well as the mean of the dependent variables and the "standard error of the regression" (for each equation), are all dencted in that table. The R^2 for each equation is also provided even though its meaning may be of a dubious value, inasmuch as the dependent variables (Q_1) in this model, are "transformed" variables and the explanatory variables are linear. The R^2 is a viable "coefficient of variation" in a situation where both the dependent and explanatory variables are linear [Sauerlender, 1973].

Since the 18 equations of the model (see Table II) are "transformed" equations, (whose form is analogous to that of equation No. 5), it can be shown that these equations can be "converted" back into a "logistic structure" as depicted in the "theoretical model" (equation No. 1). For expository purposes equation Q_1 (see Table II) is written in its "converted" form, below:

Since the left hand side of equation Q_1 for example was defined as

$Q_1 = ln\,[O_1/(1-O_1)]$

TABLE II

THE STRUCTURE OF THE MODEL^{+}

3rd Grade Reading Test Above SRP

$$Q_1 = 3.52 - \underset{(2.84)}{\underset{[.0026]}{.0075\ \text{FRV2}}} - \underset{(3.60)}{\underset{[.0033]}{.0121\ \text{FRV3}}} + \underset{(1.11)}{\underset{[.0004]}{.0005\ \text{FRV4}}} - \underset{(3.08)}{\underset{[.0035]}{.0108\ \text{FRV20}}} + \underset{(3.40)}{\underset{[.0100]}{.0343\ \text{FRV22}}} + \underset{(4.15)}{\underset{[.0119]}{.0496\ \text{FRV24}}} + \underset{(3.68)}{\underset{[.0438]}{.1617\ \text{FRV27}}} - \underset{(4.03)}{\underset{[.0031]}{.0129\ \text{FRV48}}} - \underset{(3.73)}{\underset{[.0096]}{.0359\ \text{FRV32}}}$$

$$+ \underset{(6.06)}{\underset{[.0186]}{.1132\ \text{TSCP1}}}\ ;$$

$\bar{Q}_1 = 2.96$, SER $= 0.47$, $R^2 = .76$

3rd Grade Math Test Above SRP

$$Q_2 = 2.81 - \underset{(2.19)}{\underset{[.0029]}{.0065\ \text{FRV2}}} - \underset{(2.79)}{\underset{[.0037]}{.0104\ \text{FRV3}}} + \underset{(2.38)}{\underset{[.0004]}{.0013\ \text{FRV4}}} - \underset{(3.05)}{\underset{[.0040]}{.0122\ \text{FRV20}}} + \underset{(2.05)}{\underset{[.0114]}{.0235\ \text{FRV22}}} + \underset{(3.00)}{\underset{[.0133]}{.0399\ \text{FRV24}}} + \underset{(2.50)}{\underset{[.0502]}{.1258\ \text{FRV27}}} - \underset{(1.39)}{\underset{[.1797]}{.2514\ \text{TSCP2}}} + \underset{(1.92)}{\underset{[.1628]}{.3140\ \text{APMX1}}}\ ;$$

$\bar{Q}_2 = 3.21$, SER $= 0.54$, $R^2 = .67$

6th Grade Reading Above SRP

$$Q_3 = -.39 + \underset{(2.08)}{\underset{[.0389]}{.0812\ \text{FRV14}}} + \underset{(2.97)}{\underset{[.000028]}{.000084\ \text{FRV19}}} + \underset{(2.18)}{\underset{[.0110]}{.0238\ \text{FRV24}}} - \underset{(2.39)}{\underset{[.0016]}{.0040\ \text{FRV28}}} - \underset{(2.92)}{\underset{[.0030]}{.0090\ \text{FRV51}}} + \underset{(3.49)}{\underset{[.1579]}{.5524\ \text{APMX2}}}\ ;$$

$\bar{Q}_3 = 1.05$, SER $= 0.50$, $R^2 = .53$

6th Grade Math Test Above SRP

$$Q_4 = 1.85 - \underset{(2.50)}{\underset{[.0026]}{.0067\ \text{FRV3}}} + \underset{(1.93)}{\underset{[.0005]}{.0010\ \text{FRV4}}} + \underset{(2.11)}{\underset{[.0135]}{.0286\ \text{FRV24}}} - \underset{(2.56)}{\underset{[.0019]}{.0050\ \text{FRV28}}} + \underset{(2.74)}{\underset{[.0060]}{.0167\ \text{FRV32}}} - \underset{(2.81)}{\underset{[.0269]}{.0758\ \text{TSCP1}}} - \underset{(1.49)}{\underset{[.2149]}{.3205\ \text{TSCP2}}} + \underset{(3.78)}{\underset{[.1887]}{.7140\ \text{APMX2}}}\ ;$$

$\bar{Q}_4 = 1.68$, SER $= 0.57$, $R^2 = .54$

9th Grade Math Test Above SRP

$$Q_5 = 4.81 + \underset{(2.00)}{\underset{[.0006]}{.0012\ \text{FRV5}}} - \underset{(2.52)}{\underset{[.0028]}{.0071\ \text{FRV7}}} + \underset{(1.92)}{\underset{[.0221]}{.0425\ \text{FRV31}}} + \underset{(2.88)}{\underset{[.0088]}{.0253\ \text{FRV32}}} - \underset{(5.13)}{\underset{[.0351]}{.1803\ \text{TSCP7}}} - \underset{(3.16)}{\underset{[.000006]}{.000019\ \text{COM3}}} + \underset{(1.66)}{\underset{[.2756]}{.4576\ \text{APMX3}}}\ ;$$

$\bar{Q}_5 = 0.77$, SER $= 0.97$, $R^2 = .57$

10th Grade Math Test Above SRP

$$Q_6 = -.0030 + \underset{(2.19)}{\underset{[.000039]}{.000086\ \text{FRV19}}} - \underset{(2.36)}{\underset{[.0041]}{.0098\ \text{FRV20}}} + \underset{(2.18)}{\underset{[.0007]}{.0015\ \text{FRV26}}} - \underset{(2.04)}{\underset{[.0046]}{.0095\ \text{FRV32}}} + \underset{(3.12)}{\underset{[.0212]}{.0664\ \text{FRV47}}} - \underset{(2.39)}{\underset{[.0095]}{.0227\ \text{FRV52}}} - \underset{(1.71)}{\underset{[.0170]}{.0291\ \text{TSCP8}}}\ ;$$

$\bar{Q}_6 = 0.59$, SER $= 0.50$, $R^2 = .44$

11th Grade Math Test Above SRP

$$Q_7 = -4.37 - \underset{(3.76)}{\underset{[.0070]}{.0267\ \text{FRV2}}} - \underset{(1.84)}{\underset{[.0078]}{.0143\ \text{FRV3}}} + \underset{(2.39)}{\underset{[.0829]}{.1985\ \text{FRV29}}} + \underset{(2.27)}{\underset{[.0083]}{.0190\ \text{FRV48}}} + \underset{(3.83)}{\underset{[.0541]}{.2075\ \text{TSCP7}}}\ ;$$

$\bar{Q}_7 = 0.19$, SER $= 1.43$, $R^2 = .40$

11th Grade Reading Test Above SRP

$$Q_8 = -2.04 - \underset{(2.33)}{\underset{[.0016]}{.0038\ \text{FRV5}}} - \underset{(2.20)}{\underset{[.0001]}{.0002\ \text{FRV19}}} + \underset{(1.63)}{\underset{[.0118]}{.0193\ \text{FRV48}}} - \underset{(1.50)}{\underset{[.0207]}{.0310\ \text{FRV52}}} - \underset{(1.62)}{\underset{[.4246]}{.6895\ \text{TSCP2}}} + \underset{(1.58)}{\underset{[.0542]}{.0859\ \text{TSP7}}} + \underset{(1.61)}{\underset{[.000010]}{.000016\ \text{COM3}}}\ ;$$

$\bar{Q}_8 = 1.14$, SER $= 1.04$, $R^2 = .32$

NOTE: School Districts 1, 14, 21-23, 38, 43, 47, 49, 51-54 were deleted in this run.

11th Grade Writing Test Above SRP

$$Q_9 = -1.28 - \underset{(3.49)}{\underset{[.0033]}{.0116\ \text{FRV2}}} + \underset{(2.48)}{\underset{[.0006]}{.0014\ \text{FRV5}}} - \underset{(3.08)}{\underset{[.0035]}{.0110\ \text{FRV10}}} + \underset{(1.86)}{\underset{[.0007]}{.0013\ \text{FRV25}}} + \underset{(3.06)}{\underset{[.0021]}{.0064\ \text{FRV28}}} - \underset{(1.75)}{\underset{[.0138]}{.0243\ \text{FRV33}}} - \underset{(2.55)}{\underset{[.0048]}{.0124\ \text{FRV51}}}\ ;$$

$\bar{Q}_9 = 0.38$, SER $= 0.58$, $R^2 = .32$

TABLE II
(CONTINUED)

Regents English Exam Above SRP

$$
\begin{array}{lllllll}
Q_{10} = 1.10 & - .0013\ \text{FRV5} & - .0086\ \text{FRV20} & + .0020\ \text{FRV25} & + .0309\ \text{FRV29} & - .0226\ \text{FRV33} & + .6807\ \text{APMX7}\ ; \\
 & [.0003] & [.0032] & [.0004] & [.0238] & [.0102] & [.1286] \\
 & \textit{(3.94)} & \textit{(2.68)} & \textit{(4.23)} & \textit{(2.13)} & \textit{(2.20)} & \textit{(5.29)}
\end{array}
$$

$\bar{Q}_{10} = 1.27$, SER $= 0.43$, $R^2 = .60$

Regents Math 10 Exam Above SRP

$$
\begin{array}{lllllll}
Q_{11} = .79 & - .0006\ \text{FRV5} & + .000047\ \text{FRV19} & - .0262\ \text{FRV20} & - .0218\ \text{FRV32} & + .0764\ \text{TSCP1} & + .4779\ \text{APMX6}\ ; \\
 & [.0003] & [.000040] & [.0047] & [.0059] & [.0231] & [.1822] \\
 & \textit{(1.29)} & \textit{(1.17)} & \textit{(5.08)} & \textit{(3.69)} & \textit{(3.30)} & \textit{(2.62)}
\end{array}
$$

$\bar{Q}_{11} = 1.30$, SER $= 0.61$, $R^2 = .62$

Regents Biology Exam Above SRP

$$
\begin{array}{llllll}
Q_{12} = 2.23 & - .0010\ \text{FRV5} & - .0104\ \text{FRV20} & + .0106\ \text{FRV21} & + .000005\ \text{COM3} & + .4220\ \text{APMX9}\ ; \\
 & [.0004] & [.0046] & [.0040] & [.000003] & [.2059] \\
 & \textit{(2.23)} & \textit{(2.25)} & \textit{(2.61)} & \textit{(1.31)} & \textit{(2.04)}
\end{array}
$$

$\bar{Q}_{12} = 1.56$, SER $= 0.67$, $R^2 = .33$

NOTE: School Districts 42, 43, and 51 were deleted in this run.

Regents Chemistry Above SRP

$$
\begin{array}{lllllllll}
Q_{13} = .98 & - .0170\ \text{FRV2} & + .0021\ \text{FRV5} & - .0001\ \text{FRV19} & - .0280\ \text{FRV20} & - .0870\ \text{FRV33} & + .1673\ \text{FRV49} & - .5896\ \text{TSCP2} & + .1038\ \text{TSCP7}\ ; \\
 & [.0037] & [.0007] & [.000061] & [.0058] & [.0184] & [.0747] & [.2529] & [.0325] \\
 & \textit{(4.54)} & \textit{(2.97)} & \textit{(2.52)} & \textit{(4.78)} & \textit{(4.70)} & \textit{(2.23)} & \textit{(2.33)} & \textit{(3.19)}
\end{array}
$$

$\bar{Q}_{13} = 1.44$, SER $= 0.77$, $R^2 = .64$

Regents Social Studies Above SRP

$$
\begin{array}{llllllllll}
Q_{14} = 4.25 & + .0033\ \text{FRV5} & + .0093\ \text{FRV7} & - .0002\ \text{FRV19} & - .0319\ \text{FRV20} & + .0021\ \text{FRV25} & - .0461\ \text{FRV33} & + .1718\ \text{FRV47} & - .0357\ \text{FRV48} & - .0178\ \text{FRV51} \\
 & [.0008] & [.0031] & [.000071] & [.0080] & [.0012] & [.0215] & [.0452] & [.0076] & [.0072] \\
 & \textit{(4.05)} & \textit{(2.98)} & \textit{(3.65)} & \textit{(3.97)} & \textit{(1.74)} & \textit{(2.14)} & \textit{(3.80)} & \textit{(4.65)} & \textit{(2.46)} \\
 & - 1.725\ \text{TSCP2} & + .4287\ \text{APMX7}\ ; & & & & & & & \\
 & [.3767] & [.2866] & & & & & & & \\
 & \textit{(4.58)} & \textit{(1.49)} & & & & & & &
\end{array}
$$

$\bar{Q}_{14} = 1.77$, SER $= .90$, $R^2 = .66$

Post Secondary 4 Year College

$$
\begin{array}{lllllllll}
Q_{15} = - .93 & + .0056\ \text{FRV3} & - [illegible]\ \text{FRV5} & + .0048\ \text{FRV10} & + .0146\ \text{FRV12} & + .0447\ \text{FRV24} & - .0049\ \text{FRV28} & - .0097\ \text{FRV48} & + .000011\ \text{COM3}\ ; \\
 & [.0018] & [illegible] & [.0022] & [.0047] & [.0096] & [.0011] & [.0030] & [.000002] \\
 & \textit{(3.00)} & \textit{(3.25)} & \textit{(2.17)} & \textit{(3.10)} & \textit{(4.62)} & \textit{(4.21)} & \textit{(3.17)} & \textit{(4.56)}
\end{array}
$$

$\bar{Q}_{15} = - 0.56$, SER $= 0.34$, $R^2 = .69$

Post Secondary 2 Year College

$$
\begin{array}{lllllllll}
Q_{16} = - .12 & + .0002\ \text{FRV5} & - .0627\ \text{FRV14} & - .0086\ \text{FRV20} & - .0440\ \text{FRV47} & + .0753\ \text{FRV49} & - .0123\ \text{TSCP8} & - .000007\ \text{COM3} & + .1765\ \text{APMX8}\ ; \\
 & [.0001] & [.0227] & [.0020] & [.0131] & [.0306] & [.0070] & [.000001] & [.0843] \\
 & \textit{(1.52)} & \textit{(2.75)} & \textit{(4.15)} & \textit{(3.34)} & \textit{(2.45)} & \textit{(1.74)} & \textit{(4.18)} & \textit{(2.09)}
\end{array}
$$

$\bar{Q}_{16} = - .0.98$, SER $= 0.28$, $R^2 = .59$

Employment/Military

$$
\begin{array}{lllllll}
Q_{17} = .90 & + .0048\ \text{FRV3} & - .0512\ \text{FRV24} & + .0053\ \text{FRV28} & + .0070\ \text{FRV48} & - .0312\ \text{TSCP8} & - .000067\ \text{COM2}\ ; \\
 & [.0019] & [.0105] & [.0014] & [.0022] & [.0113] & [.000017] \\
 & \textit{(2.50)} & \textit{(4.88)} & \textit{(3.78)} & \textit{(3.11)} & \textit{(2.75)} & \textit{(3.92)}
\end{array}
$$

$\bar{Q}_{17} = -0.89$, SER $= 0.38$, $R^2 = .67$

Dropout

$$
\begin{array}{lllllll}
Q_{18} = .17 & + .0016\ \text{FRV2} & - .0886\ \text{FRV14} & - .000071\ \text{FRV19} & - .0710\ \text{FRV24} & + .0040\ \text{FRV36} & - .2783\ \text{APMX7}\ ; \\
 & [.0017] & [.0467] & [.000033] & [.0130] & [.0019] & [.1851] \\
 & \textit{(.97)} & \textit{(1.89)} & \textit{(2.13)} & \textit{(5.42)} & \textit{(2.03)} & \textit{(1.50)}
\end{array}
$$

$\bar{Q}_{18} = -1.68$, SER $= 0.61$, $R^2 = .34$

---

* Standard error of coefficent (SEC) is denoted in a bracket, whereas the "t" statistics are denoted in *italics*;

$\bar{Q}_i$ = means of the transformed (dept.) variable

SER = standard error of the Regression

R^2 = R--squared; SSR = sum of Squared residuals.

this equation Q_1 (as denoted in Table II) can be written in terms of 0_1 as follows[9]:

$$6.\quad 0_1 = 1/[1 + e^{-3.38+.0075FRV2+.0121FRV3-.0005FRV4+.0108FRV20-.0343FRV22-.0494FRV24-.1617FRV27+.0129FRV48+.0359FRV52-.1132TSCPI}]$$

This equation (No. 6) which is analogous to the "theoretical model" (equation No. 1) is essentially a "technical relationship" describing how a combination of (financial) inputs will lead to a particular level of output "0_1". All other equations (in Table II) can be "converted" in a similar fashion, but additional examples are precluded from this paper.

F. Validation

The results summarized in Table II seem to confirm the "hypothesized model." A comparison of Chart I against the findings denoted in Table II reveals that many of the hypothesized variables denoted in Chart I are valid, because the corresponding "t" values are significant at a 0.05 level (i.e., $t \geq 1.64$ at 30 d.f.). However, in a few instances insignificant variables were not deleted from the equation(s) because of theoretical considerations. For instance, variable FRV4 was kept in equation Q_1, even though its corresponding "t" is low ($t=1.11$).

Moreover, the "standard error of the regression" (SER) and "sum of squares of the residuals" were found to be relatively small for many of the equations - so are many of the "standard error of the coefficients" (SEC). In several equations, however, these statistical measurements were found to have dubious values.

---

[9] Definition of variables can be found in Table I.

Consequently, validation procedures and residual analysis were carried out in general, and Chi Square test (χ^2) in particular. This test was essentially used to examine the hypothesis that the "predicted" value of school outputs generated by a given equation, have the same frequency distribution as the "actual" (observed) outputs, of the schools. As a result of this examination, some validation problems were encountered with equations Q_5 - Q_9. The Chi Square test (χ^2) concerning equations Q_7 and Q_9, for example, revealed that the aforementioned hypothesis (regarding the Chi Square test) should be rejected, whereas tests concerning equations Q_6 and Q_8 revealed that such an hypothesis can not be rejected.

Partly, these (validation) problems can be attributed to the imperfection of the "imputed" value of the dependent variables. These variables which portray the probable outcomes of a recently implemented state-administered tests (RCT), seem to reflect some flaws in the reporting schemes used (to record the result of these exams) by the districts. As a result of this problem, large "standard errors" were encountered for the above-mentioned dependent variables (Q_5 - Q_9). Nevertheless, the equations of the empirical model are said to be theoretically valid because the calibration results (as denoted by the "t" statistics) confirm the structure of the "hypothesized model" (see Chart I). However, these equations can be "improved" as discussed later in this paper.

G. Application of the Model

The empirical model can be applied to several educational finance problems. Since it shows the "technical relationships" between financial inputs and educational outcomes, the model can be used in conjunction with an 'operations research' technique while simulating the required resource mix required to realize desired educational goals (or outcomes). This amalgamated approach was suggested by Fox (1972), Cohn (1975), and demonstrated by Morgan (1977) and Spottheim/Wilson (1983). Another application is to use it as a policy simulation tool. For instance, it can be applied to the problem of state aid for the improvement of educational service, as was suggested elsewhere (Spottheim, Working Paper No. 10, October 1983).

V. IMPROVEMENT OF THE MODEL

Granted the validity of the conceptual and the empirical models, an improved model could be developed through the utilization of additional properties and concepts. For instance, one could enhance the empirical model by "lagging" (one year) the explanatory variables and recalibrating their coefficients. While the lack of readily available data has prevented us from developing such a model, it was hypothesized that such a model will enhance the "predictive" ability of all equations [Spottheim, March 1982] and equations Q_5 - Q_9 in particular. This effort would produce a quasi-dynamic" empirical model, whereas the current model is said to be a "static" one. Another possible improvement may be realized by constructing "interactive" variables. For instance, one can create an interactive variable composed of both FRV19 and TSCP8 variables and enter it into the equations as a new explanatory variable, whose coefficient is to be estimated via a ML method.

Additional improvement could be achieved by recalibration several subset of the eighteen equations simultaneously. Whereas, the current equations were calibrated separately, one could construct subsets consisted of equations: $Q_1 - Q_2$; $Q_3 - Q_4$; $Q_7 - Q_9$; $Q_{10} - Q_{14}$; $Q_{14} - Q_{18}$, and calibrate the equations of each subset simultaneously (via ML technique).

An alternative way for improving the model could be realized through the reconstruction of the model as a set of "retrospective" equations. The current model, as was noted earlier, is said to be analogous to a "prospective" model, and as such it requires a follow-up and periodic updating. A retrospective model takes into account two types of pupils; those who took the exams (case) and the others (control) who have not taken such tests [Farewell, 1979]. A retrospective model should appeal to educators, inasmuch as some of its properties (i.e., "case" and "control" samples) are analogous to those found in some "Ed-psychometric" studies. To calibrate such a model, a new data sample is needed for reconstructing the dependent variables. Such data is not readily available.

Perhaps the best improvement can be realized by constructing a "hybrid" model. For example, the empirical model could be reconstructed so as to produce a retrospective model with interactive and lagged explanatory variables, whose coefficients are simultaneously estimated (for selected subset of equations) via an ML technique.

VI. SUMMARY

In the preceding sections, the application of econometric techniques used to calibrate the empirical model were discussed and the structure of this model were formally presented. The recapitulation of this endeavor is presented below.

While general economic and research principles were used to construct the model, this endeavor was influenced by the suspicion that the empirical model is likely to be composed of a set of "logistic" equations (Spottheim, March 1983, June 1982). The examination of "raw data" along with the review of accepted body of theories reinforced this notion.

Thus, an effort was made to calibrate 18 logistic equations denoting the relationships between expenditures and pupil performances. In the course of this effort, "cross sectional" (i.e., one year) administrative data for 72 Long Island school districts was collected and analyzed. Consequently, a prototype [see Spottheim/Libassi, 1982] and this empirical model were constructed. The empirical model is said to be a "prospective" model. It was found to be statistically significant. Some equations were found to be theoretically sound but statistically inconclusive. As noted earlier, this problem can be attributed to the data-recording procedure used by the district. Finally, some suggestions were made on how to improve the model.

In sum, the application of the educational production function concepts along with econometric and statistical techniques discussed so far should not be viewed as an esoteric or mysterious process. Rather, this approach was devised to extract relevant information from numerical data concerning educational finance. The result of this effort demonstrated that an array of educational data can be reduced into a manageable set of equations. These equations summarized the educational ends and means relationships. The methodology used to construct the model is advantageous because it allows other investigators to replicate and test the model in different settings.

While the equations may not be regarded by some as useful or tangible decision-making instruments, they can be used in conjunction with a goal programming technique to simulate the allocation of resources needed to achieve predetermining educational targets as demonstrated elsewhere (Spottheim and Wilson, April 1983). An up-dated discussion of this amalgamated approach is presented in the next paper (Chapter III).

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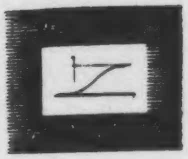

CHAPTER II
APPENDICES

APPENDIX A

579 Segment (No. of Var., 104)

Layout of DAVID'S FILE*
October 2, 1982

VAR. # ON DAVID'S FILE	COR.VAR. IN 579 FILE	CODE	DATA ELEMENT NAME/ DEFINITION OF VAR.	579 CARD COLUMNS	NUMBER OF CHARACTERS
			Record Type	1	1
			School Code	2-13	6 & 6
			School Name	17-53	36
			ENROLLMENTS		
1.	1.		1/2 K Enr. White	281-284	4
2.	2.		1/2 K Enr. Total	285-288	4
3.	3.		K Enr. White	305-308	4
4.	4.		K Enr. Total	309-312	4
5.	5.		Grade 1 Whites	329-332	4
6.	6.		Grade 2 Whites	353-356	4
7.	7.		Grade 3 Whites	377-380	4
8.	8.		Grade 4 Whites	401-404	4
9.	9.		Grade 5 Whites	425-428	4
10.	10.		Grade 6 Whites	449-452	4
11.	11.		Ungraded Elementary Whites	473-476	4
12.	12.		Ungraded Elementary Totals	477-480	4
13.	13.		Grade 7 Whites	497-500	4
14.	14.		Grade 8 Whites	521-524	4
15.	15.		Grade 9 Whites	545-548	4
16.	16.		Grade 10 Whites	569-572	4
17.	17.		Grade 11 Whites	593-596	4
18.	18.		Grade 12 Whites	617-620	4
19.	19.		Ungraded Secondary White	641-644	4
20.	20.		Ungraded Secondary Totals	645-648	4
21.	21.		Postgraduate White	665-668	4
22.	22.		Postgraduate Totals	669-672	4
23.	23.		Total K-6 Enrollment	673-676	4
24.	24.		Total 7-12 Enrollment	677-680	4
25.	25.		Total School Enrollment	681-684	4
			PROFESSIONAL STAFF		
26.	26.		Total Principals (No. of)	713-716	4
27.	27.		Total Asst. Principals	737-740	4
28.	28.		Total Classroom Teachers	761-764	4
29.	29.		Total Other Instructors	785-788	4
30.	30.		Total Part Time Teachers	809-812	4
31.	31.		F.T.E. (Full Time Equivilant) Teacher Asst. Handicapped	843-846	4
32.	32.		" Teacher Asst. Occup. Ed.	853-856	4
33.	33.		" Teacher Asst. All Other	893-896	4

*NOTE - This file ("DAVID'S") replaces the former "DAVID'S FILE" that was created 7/15/82, verified 8/15/82 and deleted October 1982. The current file contains 1979-1980 data, while the former and now deleted file contained 1977-1978 data which was used for testing purposes only.

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VAR. # ON DAVID'S FILE	COR. VAR. IN S79 FILE	CODE	DATA ELEMENT NAME/ DEFINITION OF VAR.	S79 CARD COLUMN	NUMBER OF CHARACTERS
34.	34.		FTE Teacher Aide Handicapped	873-876	4
35.	35.		FTE Teacher Aide Occ. Ed.	883-886	4
36.	36.		FTE Teacher Aide All Other	893-896	4
37.	37.		" Pupil Pers. Aides	903-906	4
38.	38.		" Library Aides	913-916	4
39.	39.		" Health Aides	923-926	4
40.	40.		" Other Para Professional Staff	933-936	4
			FACILITIES AND ROOMS [1]		
41.	41.		Regular Classrooms (No. of)	1073-1075	3
42.	42.		Kindergarten Rooms	1076-1077	2
43.	43.		Science Rooms	1078-1079	2
44.	44.		Science Labs	1080-1081	2
45.	45.		Combo Science Classroom/Lab	1082-1083	2
46.	46.		Language Lab	1084-1085	2
47.	47.		Reading Lab	1086-1087	2
48.	48.		Math Lab	1088-1089	2
49.	49.		Art Room	1090-1091	2
50.	50.		Music Room (General Vocal)	1092-1093	2
51.	51.		Music Room (Instrumental)	1094-1095	2
52.	52.		Music Room (Practice)	1096-1097	2
53.	53.		Music Room (Combined)	1098-1099	2
54.	54.		Mechanical Drawing Room	1100-1101	2
55.	55.		Industrial Arts Rooms	1102-1103	2
56.	56.		Agriculture Room	1104-1105	2
57.	57.		District Education Room	1106-1107	2
58.	58		School Store Lab	1108-1109	2
59.	59.		Health Occupation Room	1110-1111	2
60.	60.		Home Economics Room	1112-1113	2
61.	61.		Office Practice Room	1114-1115	2
62.	62.		Secretarial Practice Room	1116-1117	2
63.	63.		Typing Room	1118-1119	2
64.	64.		Trade Rooms	1120-1121	2
65.	65.		Technical Rooms	1122-1123	2
66.	66.		Other Occupational Education Rooms	1124-1125	2
67.	67.		Resource Rooms	1126-1127	2
68.	68.		Other Special Education Rooms	1128-1129	2
69.	69.		School Library/Media Rooms	1130-1131	2
70.	70.		Instructional Media/Resource Centers	1132-1133	2
71.	71.		Study Halls	1134-1135	2
72.	72.		Auditorium	1136-1137	2
73.	73.		Cafeteria/Lunch Room	1138-1139	2
74.	74.		Kitchens	1140-1141	2
75.	75.		Cafeteria/Auditorium	1142-1143	2
76.	76.		Gym Auditorium	1144-1145	2
77.	77.		Gym Cafeteria	1146-1147	2

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[1] Average [illegible] room (& lab) is 770 sq. ft.

VAR. # ON DAVID'S FILE	COR. VAR. IN S79 FILE	CODE	DATA ELEMENT NAME/ DEFINITION OF VAR.	S79 CARD COLUMNS	NUMBER OF CHARACTERS
78.	78.		Gym Cafetorium	1148-1149	2
79.	79.		Gymnasium	1150-1151	2
80.	80.		Swimming Pools	1152-1153	2
81.	81.		Total Teach. State Physical Ed.	1154-1155	2
82.	82.		Photography Dark Room	1156-1157	2
83.	83.		Multipurpose Room	1158-1159	2
84.	84.		Miscellaneous Instruction Room	1160-1161	2
			H.S. GRADUATES DESTINATION TO:		
85.	85.		Post Secondary in NYS 4 yrs.	1182-1185	4
86.	86.		" " " " 2 yrs.		4
87.	87.		" " " " Other		4
88.	88.		" " Out of NYS 4 yrs.	1194-1197	4
89.	89.		" " " " " 2 yrs.		4
90.	90.		" " " " " Other	1202-1205	4
91.	91.		Employment	1206-1209	4
92.	92.		Military	1210-1213	4
93.	93.		Other	1214-1217	4
94.	94.		TOTAL Graduates	1218-1221	4
	95.-104		Female (Same breakdown as above) Var. in S79 File(95-104) where combined with Var. 85-97 in file.		
95.	105.		Dropouts	1307-1310	4
96.	106.		Dropout Rate Dropouts/6-12 Enr.	1311-1314	4
			STUDENT CHARACTERISTICS		
97.	107.		% of Students on Welfare	1319-1320	2
98.	108.		# of Books in Library	1345-1350	6
99.	109.		# of Titles in Library	1351-1356	6
100.	110.		Students Truant	1374-1377	4
101.	111.		Average Teacher Absences	1378-1381	4
102.	112.		% Students Failed 2 Subjects	1382-1384	3
103.	113.		% Limited English Language	1462	1 (1-6)
104.	114.		% PSEN	1468-1470	3

END OF S79 SEGMENT

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Expenditure Variables-Schedule 4A -- DP49

DAVID'S FILE - continued

F79 Segment (No. of Var. - 168)

VAR. # ON DAVID'S FILE	COR. VAR. IN F79 FILE	DATA ELEMENT NAME/ DEFINITION OF VAR.	SOURCE	COMMENTS		
				Acct. Code	DP Code	
		BOARD OF EDUCATION EXPENDITURES				
105	1.	Total Board of Education Expenditures	**All From File F79	1010.0	005	*
106	2.	Total District Clerk Expenditures		1040.0	010	*
107	3.	Total District Meeting Expenditures		1060.0	015	*
108	4.	TOTAL BOARD OF EDUCATION EXPENDITURES		1099.0	016	
		CENTRAL ADMINISTRATION				
109	5.	Instructional Salaries (Chief School Administrator)		1240.15	017	*
110	6.	Non-Instructional Salaries "		1240.16	018	*
111.	7.	Equipment "		1240.2	019	
112.	8.	Contractual and Other "		1240.4	020	*
113.	9.	Supplies and Materials "		1240.45	021	*
114.	10.	Total Chief School Administrator		1240.0	022	*
115	11.	Total Business Administration		1310.0	030	*
116	12.	Total Auditing		1320.0	035	*
117.	13.	Total Treasurer		1325.0	040	*
118.	14.	TOTAL FINANCE		1399.0	055	
		STAFF				
119	15.	Total Legal		1420.0	061	*
120	16.	Total Personnel		1430.0	068	*
121	17.	Total Public Information and Service		1480.0	075	*
122	18.	TOTAL STAFF		1499.0	076	
		CENTRAL SERVICES				
123	19.	Noninstructional Salaries		1620.16	077	
124	20.	Equipment		1620.2	078	
125	21.	Contractual and Other		1620.4	079	
126	22.	Supplies and Materials		1620.45	080	
127	23.	Total Operation and Maintenance Of Plant		1620.0	081	*
128	24.	Total Central Printing and Mailing		1670.0	092	*
129	25.	Total Central Data Processing		1680.0	098	*
130	26.	TOTAL CENTRAL SERVICES		1699.0	099	
		SPECIAL ITEMS				
131	27.	Unallocated Insurance		1910.4	100	*
132	28.	Judgements and Claims		1930.4	102	*
133	29.	Administrative Charge - BOCES		1981.49	105	*
134	30.	TOTAL GENERAL SUPPORT		1999.0	109	

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*For Fred's Work
**All From File F79

1979 General Fund Expenditure Variables - continued

"F79 Segment - continued

VAR. # ON DAVID'S FILE	COR. VAR. IN F79 FILE	DATA ELEMENT NAME/ DEFINITION OF VAR.	SOURCE	COMMENTS		
				Acct Code	DP Code	
		INSTRUCTION--ADMINISTRATION AND IMPROVEMENT				
135	31.	Instructional Salaries - Curricul. Dev. & Sup.		2010.15	110	
136	32.	Non-Instructional Salaries		2010.16	111	
137	33.	Equipment		2010.2	112	
138	34.	Contractual and Other		2010.4	113	
139	35.	Supplies and Materials		2010.45	114	
140	36.	BOCES Services		2010.49	115	
141	37.	Total Curriculum Development and Supervision		2010.0	116	*
142	38.	Instructional Salaries - Supervision		2020.15	117	
143	39.	Non-Instructional Salaries		2020.16	118	
144	40.	Equipment		2020.2	119	
145	41.	Contractual and Other		2020.4	120	
146	42.	Supplies and Materials		2020.45	121	
147	43.	BOCES Services		2020.49	122	
148	44.	Total Supervision - regular School		2020.0	123	*
149	45.	Instructional Salaries		2060.15	130	
150	46.	Non-Instructional Salaries		2060.16	131	
151	47.	Equipment		2060.2	132	
152	48.	Contractual and Other		2060.4	133	
153	49.	Supplies and Materials		2060.45	134	
154	50.	BOCES Services		2060.49	135	
155	51.	Total Research, Planning, and Evaluation		2060.0	136	
156	52.	Instructional Salaries - In Service Training		2070.15	137	
157	53.	Non-Instructional Salaries		2070.16	138	
158	54.	Equipment		2070.2	139	
159	55.	Contractual and Other		2070.4	140	
160	56.	Supplies and Materials		2070.45	141	
161	57.	BOCES Services		2070.49	142	
162	58.	TOTAL INSERVICE TRAINING--INSTRUCTION		2070.0	143	*
		INSTRUCTION--TEACHING				
163	59.	Teacher Salaries, K-6		2110.12	147	*
164	60.	Teachers Salaries, 7-12		2110.13	148	*
165	61.	Substitute Teacher Salaries		2110.14	149	*
166	62.	Non-Instructional Salaries		2110.16	150	*
167	63.	Equipment		2110.2	151	*
168	64.	Contractual and Others		2110.4	152	*
169	65.	Supplies and Materials		2110.45	153	*
170	66.	Tuition		2110.47	154	*
171	67.	Textbooks		2110.48	155	*
172	68.	BOCES Services		2110.49	156	*
173	69.	TOTAL TEACHING - REGULAR SCHOOL		2110.0	157	

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1979 General Fund Expenditure Variables - continued

F79 Segment

VAR. # ON DAVID'S FILE	COR. VAR. IN F79 FILE	DATA ELEMENT NAME/ DEFINITION OF VAR.	SOURCE	COMMENTS Acct. Code	F79 DP Code	
		SPECIAL APPORTIONMENT PROGRAMS				
174	70.	Total Program for Handicapped Children		2230.0	166	* Correspond To PSEN Pupil Information S79 File
175	71.	Total Program for Children With Learning Disabilities		2255.0	175	*
176	72.	TOTAL SERVICES FOR PUPILS WITH SPECIAL NEEDS		2270.0	183	*
		INSTRUCTIONAL MEDIA				
177	73.	Instructional Salaries - Library		2610.15	202	*
178	74.	Non-Instructional Salaries		2610.16	203	*
179	75.	Equipment		2610.2	204	*
180	76.	Contractual and Other		2610.4	205	*
181	77.	Supplies and Materials		2610.45	206	*
182	78.	BOCES Services		2610.49	207	
183	79.	Total School Library and Audiovisual		2610.0	208	*
184	80.	Total Educational Television		2620.0	215	
185	81.	Instructional Salaries Computer Services		2630.15	216	
186	82.	Non-Instructional Salaries		2630.16	217	
187	83.	Equipment		2630.2	218	
188	84.	Contractual and Other		2630.4	219	
189	85.	Supplies and Materials		2630.45	220	
190	86.	BOCES Services		2630.49	221	
191	87.	Total Computer Assisted Instruction		2630.0	222	
192	88.	TOTAL INSTRUCTIONAL MEDIA		2699.0	223	
		PUPIL SERVICES (PUPIL PERSONNEL SERVICES AND PUPIL ACTIVITIES)				
193	89.	Total Attendance - Regular School		2805.0	230	*
194	90.	Instructional Salaries		2810.15	231	*
195	91.	Non-Instructional Salaries		2810.16	232	*
196	92.	Equipment		2610.2	233	*
197	93.	Contractual and Others		2810.4	234	*
198	94.	Supplies and Materials		2810.45	235	*
199	95.	BOCES Services		2810.49	236	
200.	96.	Total Guidance - Regular School		2810.0	237	
201	97.	Instructional Salaries Health Services		2815.15	238	
202	98.	Non-Instructional Salaries		2815.16	239	*
203	99.	Equipment		2815.2	240	*
204	100.	Contractual and Other		2815.4	241	*
205	101.	Supplies and Materials		2815.45	242	*
206	102.	BOCES Services		2815.49	243	
207	103.	Total Health Services - Regular School		2815.0	244	*

DAVID'S FILE - continued

1979 General Fund Expenditure Variables - continued

VAR. # ON DAVID'S FILE	"F79 Segment COR.VAR. IN F79 FILE	DATA ELEMENT NAME/ DEFINITION OF VAR.	SOURCE	COMMENTS Acct. Code	F79 DP Code	
208	104.	Instructional Salaries	Psych. Service	2820.15	245	*
209	105.	Non-Instructional Salaries	" "	2820.16	246	
210	106.	Equipment	" "	28[illegible].2	247	*
211	107.	Contractual and Other	" "	2820.4	248	*
212	108.	Supplies and Materials	" "	2820.45	249	*
213	109.	BOCES Services	" "	2820.49	250	
214	110.	Total Psychological Services - Regular School		2820.0	251	*
215	111.	Instructional Salaries	Social Work Services	2825.15	252	
216	112.	Non-Instructional Salaries	" " "	2825.16	253	
217	113.	Equipment	" " "	2825.2	254	
218	114.	Contractual and Others	" " "	2825.4	255	
219	115.	Supplies and Materials	" " "	2825.45	256	
220	116.	BOCES Services		2825.49	257	
221	117.	Total Social Work Services - Regular School		2825.0	258	
222	118.	Instructional Salaries	CoCorricular Activity	2850.15	266	
223	119.	Non-Instructional Salaries	" "	2850.16	267	
224	120.	Equipment	" "	2850.2	268	
225	121.	Contractual and Other	" "	2850.4	269	
226	122.	Supplies and Materials		2850.45	270	
227	123.	Total Cocurricular Activities - Regular School		2850.0	271	*
228	124.	Instructional Salaries	Interscholastic Athletics	2855.15	272	
229	125.	Non-Instructional Salaries	" " "	2855.16	273	
230	126.	Equipment	" " "	2855.2	274	
231	127.	Contractual and Other	" " "	2855.4	275	
232	128.	Supplies and Materials	" " "	2855.45	276	
233	129.	BOCES Services	" " "	2855.49	277	
234	130.	Total Interscholastic Athletics - Regular School		2855.0	278	*
235	131.	TOTAL PUPIL SERVICE		2855.0	279	
236	132.	Total Instruction (Salaries)		2999.0	280	
		PUPIL TRANSPORTATION				
237	133.	Non-Instructional Salaries		5510.16	281	
238	134.	Total District Transportation		5510.0	287	
239	135.	TOTAL PUPIL TRANSPOR ATION		5999.0	296	*
		COMMUNITY SERVICES - RECREATION				
240	136.	Instructional Salaries		7140.15	304	
241	137.	Non-Instructional Salaries		7140.16	305	
242	138.	Equipment		7140.2	306	
243	139.	Contractual and Other		7140.4	307	
244	140.	Supplies and Materials		7140.45	308	
245	141.	BOCES Services		7140.49	309	
246	142.	Total Community Recreation		7140.0	310	

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1979 General Fund Expenditure Variables - continued

"F79 Segment continued

VAR. # ON DAVID'S FILE	COR.VAR. IN F79 FILE	DATA ELEMENT NAME/ DEFINITION OF VAR.	SOURCE	COMMENTS Acct. Code	COMMENTS F79 DP Code	
247	143.	Instructional Salaries	Youth Program	7310.15	311	
248	144.	Non-Instructional Salaries	" "	7310.16	312	
249	145.	Equipment	" "	7310.2	313	
250	146.	Contractual and Other	" "	7310.4	314	
251	147.	Supplies and Materials	" "	7310.45	315	
252	148.	BOCES Services	" "	7310.49	316	
253	149.	Total Youth Program		7310.0	317	
254	150.	TOTAL RECREATION		7310.0	318	
		OTHER COMMUNITY SERVICES				
255	151.	Instructional Salaries - Civic		8060.15	319	
256	152.	Non-Instfuctional Salaries		8060.16	320	
257	153.	Equipment		8060.2	321	
258	154.	Contractual and Others		8060.4	322	
259	155.	Supplies and Materials		8060.45	323	
260	156.	BOCES Services		8060.49	324	
261	157.	Total Civic Activities		8060.0	325	
262	158.	Non-Instructional Salaries CENSUS		8070.16	326	
263	159.	Equipment		8070.2	327	
264	160.	Contractual and Others		8070.4	328	
265	161.	Supplies and Materials		8070.45	329	
266	162.	BOCES Services		8070.49	330	
267	163.	Total Census		8070.0	331	
268	164.	Total Other Community Services		8998.0	332	
769	165	TOTAL COMMUNITY SERVICES		8999.0	333	*
		UNDISTRIBUTED EXPENDITURES				
270	166.	Total Employee Benefits		9098.0	344	*
271	167.	Total Undistributed Expenditure		9899.0	386	
272	168.	TOTAL GENERAL FUND EXPENDITURES		9999.0	396	

END OF F79 SEGMENT

D79 FILE Segment (No. of Var. - 20)

DAVID'S FILE

VAR. # ON DAVID'S FILE	COR. VAR. IN D79 FILE	CODE	DATA ELEMENT NAME/ DEFINITION OF VAR.	D79 CARD COLUMNS	NUMBER OF CHARACTERS
			District Code	2-13	12
			District Name	53-88	36
273	1.		Salary/Chief Officer	247-252	6
274	2.		Non Professional Secretaries F.T.	393-398	6
275	3.		Non Professional Secretaries P.T.	399-404	6
276	4.		Maintenance F.T.	405-410	6
277	5.		Maintenance P.T.	411-416	6
278	6.		Bus Drivers F.T.	417-422	6
279	7.		Bus Drivers P.T.	423-428	6
280	8.		School Lunch Workers F.T.	429-434	[illegible]
281	9.		School Lunch Workers P.T.	435-440	[illegible]
282	10.		Other Non-Professional Staff F.T.	441-446	6
283	11.		Other Non-Professional Staff P.T.	447-452	6
284	12.		Tardiness (Teachers?)	633-640	8
285	13.		% of Pupils Below State Ref. Point (SRP) Grade 3 reading exam (Fall 1979)*		
286	14.		% of Pupils Below SRP - Grade 3 math exam (1979)		
287	15.		% of Pupils Below SRP - Grade 6 reading exam (1979)		
288	16.		% of Pupils Below SRP - Grade 6 math exam (1979)		
289	17.		% of Pupils Below SRP - Grade 3 reading exam (Fall 1980)		
290	18.		% of Pupils Below SRP - Grade 3 math exam (1980)		
291	19.		% of Pupils Below SRP - Grade 6 reading exam (1980)		
292	20.		% of Pupils Below SRP - Grade 6 math exam (1980)		

END OF D79 SEGMENT

*NOTE - The value of 101 indicates missing information. Cases with such value should be excluded from the sample before calibrating the models. Data was obtained from N.Y.S. Department of Education - State Pupil Proficiency Testing.

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Municipal Affair Revenue Expenditure Variables
For FY Ending June, 1980.

M79 File Segment (No. of Var., 30)

DAVID'S FILE

VAR. # ON DAVID'S FILE	COR. VAR. IN M79 FILE	CODE	DATA ELEMENT NAME/ DEFINITION OF VAR.	SOURCE	COMMENTS/ CARD COLUMN
			REVENUE		
293	1.		Real Property Taxes	Municipal Affair No. 92, FY Ending 1980[1] - (p.228)	Col. 1, line 733-803[2]
294	2.		Non-Property Tax	(p.228)	Col. 2
295	3.		State Aid	(p.228)	Col. 3 #
296	4.		Federal Aid	(p.228)	Col. 4 #
297	5.		Interest on Investment	(p.228)	Col. 5 #
298	6.		Other Revenues	(p.229)	Col. 5
299	7.		Total Revenue[3]	(p.228)	Col. 7 #
300	8.		Bonds (Borrowing)	(p.229)	Col. 1
301	9.		Notes (Borrowing)	(p.229)	Col. 2
302	10.		Premiums & Accrued Interest (Borrowing)	(p.229)	Col. 3
303	11.		Total (Borrowing)	(p.229)	Col. 4
304	12.		Total Revenue and Borrowing[4]	(p.229)	Col. 5#
305	13.		Operating Balance at the Beginning of the FY 1980	(p.229)	Col. 6 #
			EXPENDITURE		
306	14.		General Expenditure	(p.230)	Col. 1 #
307	15.		Special Activities	(p.230)	Col. 2 #
308	16.		Capital Outlay	(p.230)	Col. 3 #
309	17.		Bonds and Anticipated Notes	(p.230)	Col. 4 #
310	18.		Principal Debt (Bond Anticip./Other)	(p.230)	Col. 5 #
311	19.		Interest Debt	(p.230)	Col. 6 #
312	20.		Total Expenditure	(p.230)	Col. 7 #
313	21.		Operating Balance End of FY 1980	(p.230)	Col. 8 #
			FISCAL BACKGROUND		
314	22.		Enrolled Pupils	(p.231)	Col. 1 #
315	23.		Real Property Assessed Value (in$)	(p.231)	Col. 2 #
316	24.		Real Property Full Value (in$)	(p.231)	Col. 3 #
317	25.		Property Tax Levy (in$)	(p.231)	Col. 3 #
318	6.		Tax Rate - % of Full Value	(p.231)	Col. 5 #
319	27.		Bonds (Outstanding) - ($)	(p.231)	Col. 6 #
320	28.		Bonds and Anticipated Notes	(p.231)	Col. 7
321	29.		Other Notes	(p.231)	Col. 8
322	30.		Income per Return 1979 (in$)	State Income Tax	#

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[1] Municipal Affair No. and FY remain the same.

[2] Line No. remains the same.

[3] Interest on Investment and Other Revenue could be computed by subtracting information in Col. 1, 3 and 4 from Col.7 (p.228)

[4] Borrowing could be obtained by subtracting Col 5, (p.229) information from Col. 7, (p.228)

# Indicates usefull variable. Other variables contain insufficient data and should be excluded from the model.

APPENDIX B

THE ENHANCED
PUPIL PERFORMANCE AND RESOURCE UTILIZATION MODEL

Modified October

Corrected Nov. 1, 1983
Jan. 31, 1984
March 12, 1984

LIST OF VARIABLES GENERATED BY
MAKE 15 NEW PROGRAM

September, 1983

I. RAW DEPENDENT VARIABLES

A. Exam Results (Elementary School); Probability Measurements

Var. No.		File/Var. Name	Corresp. Variable in Files
O_1	Reading Exam 3rd Grade - Above State Reference Point (SRP)	David's	1 - [X(289)/100]
O_2	Math " " " " " " "	"	1 - [X(290)/100]
O_3	Reading Exam 6th Grade - " " " "	"	1 - [X(291)/100]
O_4	Math " " " " " " "	"	1 - [X(292)/100]

B. RCT Exam Results (Sec. Schools); Probability Measurements

O_5	Math Exam 9th Grade - Above SRP	DATA RCT 280	RCT 4/RCT 3
O_6	" " 10th " "	"	RCT 6/RCT 5
O_7	" " 11th " "	"	RCT 8/RCT 7
O_8	Reading " " " "	"	RCT 2/RCT 1
O_9	Writing " " " "	"	RCT 10/RCT 9

C. Regents Graduation Exams; Probability Measurements

O_{10}	Regents English Exam - Above SRP	DATA RGNTS 80	RGNT 2/RGNT 1
O_{11}	" Math 10 " "	"	RGNT 4/RGNT 3
O_{12}	" Biology " "	"	RGNT 6/RGNT 5
O_{13}	" Chemistry " "	"	RGNT 8/RGNT 7
O_{14}	" Social Studies "	"	RGNT 10/RGNT 9

D. Destination of High School Graduates; Probability Measurements

O_{15}	Post Secondary 4 Years College	See; Make 14 (old) & David's file	As defined by Variable O(1) Make 14 (Old)
O_{16}	Post Secondary 2 Years College		As defined by Variable O(2)
O_{17}	Employment/Military		As defined by Variable O(3)
O_{18}	Dropout		As defined by Variable O(4)
O_{19}	Other		As defined by Variable O(5)

II. TRANSFORMED DEPENDENT VARIABLES (LOGIT)

A. Exam Results (Elementary School)

Q_1	Reading Exam 3rd Grade - Above State Reference Point (SRP)	Transformed O_i Var. Defined Above	*ln* O(1)/[1-O(1)] **
Q_2	Math " " " " " " "	"	*ln* O(2)/[1-O(2)]
Q_3	Reading " 6th " " " " "	"	*ln* O(3)/[1-O(3)]
Q_4	Math " " " " " " "	"	*ln* O(4)/[1-O(4)]

B. RCT Exam Results (Sec. Schools)

			ln
Q_5	Math Exam 9th Grade - Above SRP	"	*ln* O(5)/[1-O(5)]
Q_6	" " 10th " "	"	*ln* O(6)/[1-O(6)]
Q_7	" " 11th " "	"	*ln* O(7)/[1-O(7)]
Q_8	Reading " " " "	"	*ln* O(8)/[1-O(8)]
Q_9	Writing " " " "	"	*ln* O(9)/[1-O(9)]

**ln = A symbol denoting natural log.

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C. Regents Graduation Exams

		File/Var. Name	
Q_{10}	Regents English Exam - Above SRP	A Transformed Var. As Defined Above	*ln* O(10)/[1-O(10)]
Q_{11}	" Math 10 " "	"	*ln* O(11)/[1-O(11)]
Q_{12}	" Biology " "	"	*ln* O(12)/[1-O(12)]
Q_{13}	" Chemistry " "	"	*ln* O(13)/[1-O(13)]
Q_{14}	" Social Studies "	"	*ln* O(14)/[1-O(14)]

D. Destination of High School Graduates

Q_{15}	Post Secondary 4 Years College	"	*ln* O(15)/[1-O(15)]
Q_{16}	Post Secondary 2 Years College	"	*ln* O(16)/[1-O(16)]
Q_{17}	Employment/Military	"	*ln* O(17)/[1-O(17)]
Q_{18}	Dropout	"	*ln* O(18)/[1-O(18)]
Q_{19}	Other	"	*ln* O(19)/[1-O(19)]
	O(51) through O(91)	Make 14	Inserted variables tak from Make 14 (Old)

III. EXPLANATORY, FINANCIAL RESOURCE AND OTHER INPUT VARIABLES

A. Financial Resource Variables (Measured in dollar per pupil unit)

Code of Var. Incl.			MAKE 14 PROG OLD CODE		CORRES. VAR. IN DAVID'S AND/OR MAKE 14 (OLD) FILES
	FRV_1	General Support Expenditures (less Chief School Adm. Aide)	Y_{51}	=	[X(134) - X(114)]/X(25)
x_1	FRV_2	Instructional Salaries - Chief School Admin.	Y_{52}	=	X(114)/X(25)
x_2	FRV_3	Instructional Salaries - Admin., Improvmnt. & Planning	Y_{57}	=	[X(135) + X(142) + X(149) + X(156)]/X(25)
x_3	FRV_4	Instructional Salaries - Teachers K-6	Y_{61}	=	X(163)/X(23)
x_4	FRV_5	Instructional Salaries - Teachers 7-12	Y_{62}	=	X(164)/X(24)
	FRV_6	Equipment, Supply, Material, Textbooks	Y_{66}	=	[X(167) + X(169) + X(171)]/X(25)
x_5	FRV_7	Total Expenditure for PSEN per PSEN Pupil	Y_{68}	=	X(176)/[X(25) X (X(104)/100)]
	FRV_8	Instructional Salaries - Media	Y_{69}	=	[X(177) + X(185)]/X(25)
	FRV_9	Equipment, Supply, Material - Media	Y_{71}	=	[X(179) + X(181) + X(187) + X(189)]/X(25)
x_6	FRV_{10}	Instructional Salaries - Pupil Health, Psych. Soc. Ser.	Y_{74}	=	[X(194) + X(201) + X(208) + X(215)]/X(25)
	FRV_{11}	Pupil Interschol. Athletic Ser. - Instruct. Salaries	Y_{79}	=	[X(228)]/X(25)
x_7	FRV_{12}	Total Interscholastic Athletics	Y_{83}	=	[X(234)]/X(25)
	FRV_{13}	Total Pupil Transportation	Y_{86}	=	X(239)/X(25)
x_8	FRV_{14}	Community/Youth Service-Instructional Salaries	Y_{87}	=	[X(240) + X(247) + X(255)]/X(25) (Excl. from Model)
	FRV_{15}	Employee Benefits Total	Y_{92}	=	X(270)/X(25)
	FRV_{16}	Sum of Selected Non-Instructional Salaries	Y_{118}	=	O(53) + O(58) + O(65) + O(70) + O(75) + O(80) + O(88
	FRV_{17}	Sum of Selected Expenditures on Equipment, Supply, Material	Y_{119}	=	O(54) + O(59) + O(76) + O(81) + O(89)
	FRV_{18}	Sum of Selected Contractual, BOCES and Other Expenditures	Y_{120}	=	O(55) + O(60) + O(67) + O(72) + O(77) + O(82) + O(91
x_9	FRV_{19}	Average Teacher Salary Total (K-12) (not per pupil unit)	Y_{140}	=	[X(163) + X(164) + X(165)]/[X(28) + 0.5 X(30)]
x_{10}	FRV_{20}	Other Instructional Expenditures	Y_{141}	=	[X(165) + X(170)]/X(25)

Code of Var. Incl.		CORRES. VAR. IN DAVID'S AND/OR MAKE 14 (OLD) FILES
x_{11}	FRV_{21} School Library Total	$[X(183)]/X(25)$
x_{12}	FRV_{22} Computer Service/Ed. TV Total	$[X(184) + X(191)]/X(25)$
	FRV_{23} Media Total	$FRV_{21} + FRV_{22}$
x_{13}	FRV_{24} Co-Curricular Total	$[X(227)]/X(25)$
x_{14}	FRV_{25} General Support & Emply Benefit (overhead)	$FRV_{1} + FRV_{15}$
x_{15}	FRV_{26} Pupil Transport. & Maintain. Total (overhead)	$[X(127) + X(230)]/X(25)$
	BOCES	
x_{16}	FRV_{27} BOCES-Adm/Plan/Improvement Expenditure	$[X(140) + X(147) + X(154) + X(161)]/X(25)$
x_{17}	FRV_{28} BOCES-Inst. Teaching	$[X(172)]/(25)$
x_{18}	FRV_{29} BOCES-Pupil & Comm. Services	$[X(199) + X(206) + X(213) + X(245) + X(252) + X(260) + X(266)]/X(25)$
	FRV_{30} BOCES-Total	$FRV_{27} + FRV_{28} + FRV_{29}$
	CONTRACTUAL(& TUITION)	
x_{19}	FRV_{31} Contractual-Adm/Plan/Improvement	$[X(138) + X(145) + X(152) + X(159)]/X(25)$
x_{20}	FRV_{32} Contractual-Inst. Teaching and Tuition	$[X(168)]/(25)$
x_{21}	FRV_{33} Contractual-Pupil & Comm. Services	$[X(197) + X(204) + X(211) + X(218) + X(243) + X(250) + X(258) + X(264)]/X(25)$
	FRV_{34} Contractual-Total	$FRV_{31} + FRV_{32} + FRV_{33}$
	BOCES & CONTRACTUAL	
	FRV_{35}	$FRV_{27} + FRV_{31}$
x_{22}	FRV_{36}	$FRV_{28} + FRV_{32}$
	FRV_{37}	$FRV_{29} + FRV_{33}$
	FRV_{38} Total	$FRV_{30} + FRV_{34}$
	SUPPLY, MATERIAL & TEXTBOOK	
	FRV_{39} Supply-Adm/Plan/Improvement	$[X(139) + X(146) + X(153) + X(160)]/X(25)$
	FRV_{40} Supply-Inst. Teaching	$[X(169) + X(171)]/X(25)$
	FRV_{41} Supply-Pupil & Comm. Services	$[X(198) + X(205) + X(212) + X(219) + X(244) + X(251) + X(259) + X(265)]/X(25)$
	FRV_{42} Supply-Total	$FRV_{39} + FRV_{40} + FRV_{41}$
	EQUIPMENT	
	FRV_{43} Equipment-Adm/Plan/Improvement	$[X(137) + X(144) + X(151) + X(158)]/X(25)$
	FRV_{44} Equipment - Inst. Teaching	$[X(167)]/X(25)$
	FRV_{45} Equipment-Pupil & Comm. Services	$[X(196) + X(203) + X(210) + X(217) + X(242) + X(249) + X(257) + X(263)]/X(25)$
	FRV_{46} Equipment-Total	$FRV_{43} + FRV_{44} + FRV_{45}$
	SUPPLY MATERIAL, TEXTBOOK & EQUIPMENT	
x_{23}	FRV_{47}	$FRV_{39} + FRV_{43}$
x_{24}	FRV_{48}	$FRV_{40} + FRV_{44}$
x_{25}	FRV_{49}	$FRV_{41} + FRV_{45}$
	FRV_{50} Total	$FRV_{42} + FRV_{46}$
	NON-INSTRUCTIONAL SALARIES	
x_{26}	FRV_{51} Non-Inst. Sal.-Adm/Pla/Improvement/Teaching	$[X(136) + X(143) + X(150) + X(157) + X(164)]/X(25)$
x_{27}	FRV_{52} Non-Inst. Sal.-Pupil & Comm. Services	$[X(195) + X(202) + X(209) + X(216) + X(241) + X(248) + X(256) + X(262)]/X(25)$
	FRV_{53} Non-Inst. Sal.-Total	$FRV_{51} + FRV_{52}$

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B. Teacher/School, Community and Pupil Attributes Indices

			FILE NAME OR MAKE 14 PROG. OLD CODE	CORRES. VAR. IN DAVID'S FILES
X_{28}	TSCP$_1$	No. of Book-Titles in the Library		X(99)/X(25)
X_{29}	TSCP$_2$	School Size Index (1 if more then 4800 pupils; 0 Otherwise)		[X(100)/X(25)] X 100
	TSCP$_3$	Average Teacher Absence		X(101)
	TSCP$_4$	% of Pupil Failed in 2 Subjects		X(102)
	TSCP$_5$	% of Limited English Language		X(103)
	TSCP$_6$	% of PSEN		X(104)
X_{30}	TSCP$_7$	Sq./ft. of Class Room per Pupil-a crowdness index		[X(41)*770]/X(25)
X_{31}	TSCP$_8$	School Teacher Characteristics Index[4]	DATA-SCHTCH (See Col. 5)	FS*[(0.5 TCHYRED) + TCHYREX]
	COM$_1$	Real Value of Privately Owned Residential Property[1] denotes community attributes	C_{142} =	[[Z(3) - Z(4)]* Z(5)]/X(25)
X_{32}	COM$_2$	Income per Return - denotes community attributes[2]	C_{117} =	X(322)
X_{33}	COM$_3$	Community Wealth Index[3]		WLTINDX = WLT2/X(25)
	PUPNX$_1$	Index of 3rd grade attributes (a dummy variable;[5] = 1 iff probability of school is above county (or state) wide average; = 0 otherwise)[3] time "t-3"	See 3RD6TH77	3rd. Col.
	PUPNX$_2$	Index of 6th grade attributes (a dummy variable; = 1 iff probability of school is above county (or state) wide average performance; time "t-3" otherwise =0)	"	5th Col.
	PUPNX$_3$	Index of 9th grade attributes (= 1 iff probability of school is above county (or state) wide average performance; = 0 otherwise) time "t-1"	See SFS.BCT-PCT79JUN	
	PUPNX$_4$	Index of 10th grade attributes (= 1 iff probability of school is above county (or state) wide average; = 0 otherwise) time "t-1"	"	
	PUPNX$_5$	Index of 11th grade attributes (= 1 iff probability of school is above county (or state) wide average; = 0 otherwise) time "t-1"	"	
	PUPNX$_6$	11th Grade reading/writing (combined) Index		

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[1] Derived from census data variables Z(3), Z(4), Z(5) can be found in SATADATA file

[2] Measured in terms of $ per income tax returns

[3] Community wealth index variable (COM$_3$) is derived as follows:
Let;

ASST = [Z(3) - Z(4)]* Z(5); SATADATA file
WLT2 = INC1 + INC2 + ½* ASST; see DATAWEALTH2 file
TXPD = X(318) * ASST; (X(318) is in David's file)
EFRT = TXPD/WLT2

Then Community Wealth (WLTINDX);

WLTINDX = WLT2/X(25); X(25) = Enrollees

Where; (*) = Multiplication Symbol

[4] School/Teacher Characteristics Index is derived as a ratio of;

[1/2 years of teacher's ed. + years of teacher exp.]/pupils per teacher.

Data can be found in:

File Name	Variable Code
DATA-TCH-DEG	TCHYRED (col. 12) 1 = HS; 10=PHD
DATA-TCHEXP	TCHYREX (col. 1)
DATA-F-S-80M	FS (col.12)

[5] Note PUPNX$_i$ and APNX$_i$ are binary (dummy) variables.

C. Pupil Characteristics Previous Year

	Var. Code	Var. Name	Source
X_{34}	$APNX_1$	3rd grade pupil perf. index time "t-1"[5]	Retrieved from 3RD6TH-79 3rd col.
X_{35}	$APNX_2$	6th grade " " " " "	" " " 5th col.
X_{36}	$APNX_3$	9th grade math RCT " " "	$PUPNX_3$ generated by Make 15
X_{37}	$APNX_4$	10th grade math RCT " " "	$PUPNX_4$ " " " "
	$APNX_5$	11th grade math RCT " " "	$PUPNX_5$ " " " "
	$APNX_6$	11th grade (RW) RCT " " "	$PUPNX_6$ " " " "
X_{38}	$APNX_7$	Regents English " " "	
X_{39}	$APNX_8$	Regents Math 10 " " "	generated from SFS.REG79 file
X_{40}	$APNX_9$	Regents Biology " " "	" " " "
	$APNX_{10}$	Regents Chemistry " " "	" " " "
	$APNX_{11}$	Regents Social Studies " " "	" " " "
	$APNX_{12}$	% of students truant [X(100)/X(25)] X 100	" " " "

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[5] Note $PUPNX_1$ and $APNX_1$ are binary (dummy) variables.

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APPENDIX C

THE ENHANCED
PUPIL PERFORMANCE AND RESOURCE UTILIZATION MODEL

Modified October
Corrected Nov. 1, 1983

LIST OF VARIABLES GENERATED BY
MAKE 15 NEW PROGRAM

September, 1983

RAW DEPENDENT VARIABLES

A. Exam Results (Elementary School)

Var. No.		File/Var. Name	Corresp. Variable in Files
O_1	Reading Exam 3rd Grade - Above State Reference Point (SRP)	David's	1 - [X(289)/100]
O_2	Math " " " " " " "	"	1 - [X(290)/100]
O_3	Reading Exam 6th Grade - " " " "	"	1 - [X(291)/100]
O_4	Math " " " " " " "	"	1 - [X(292)/100]

B. RCT Exam Results (Sec. Schools)

O_5	Math Exam 9th Grade - Above SRP	DATA RCT 280	RCT 4/RCT 3
O_6	" " 10th " "	"	RCT 6/RCT 5
O_7	" " 11th " "	"	RCT 8/RCT 7
O_8	Reading " " " "	"	RCT 2/RCT 1
O_9	Writing " " " "	"	RCT 10/RCT 9

C. Regents Graduation Exams

O_{10}	Regents English Exam - Above SRP	DATA RGNTS 80	RGNT 2/RGNT 1
O_{11}	" Math 10 " "	"	RGNT 4/RGNT 3
O_{12}	" Biology " "	"	RGNT 6/RGNT 5
O_{13}	" Chemistry " "	"	RGNT 8/RGNT 7
O_{14}	" Social Studies "	"	RGNT 10/RGNT 9

D. Destination of High School Graduates

O_{15}	Post Secondary 4 Years College	See: Make 14 (old) & David's file	As defined by (Variable O(1)) Make 14 (Old)
O_{16}	Post Secondary 2 Years College		
O_{17}	Employment/Military		
O_{18}	Dropout		
O_{19}	Other		

TRANSFORMED DEPENDENT VARIABLES (LOGIT)

A. Exam Results (Elementary School)

Q_1	Reading Exam 3rd Grade - Above State Reference Point (SRP)	Transformed Var. as Defined Above	O(1)/[1-O(1)]
Q_2	Math " " " " " " "	"	O(2)/[1-O(2)]
Q_3	Reading " 6th " " " " "	"	O(3)/[1-O(3)]
Q_4	Math " " " " " " "	"	O(4)/[1-O(4)]

B. RCT Exam Results (Sec. Schools)

Q_5	Math Exam 9th Grade - Above SRP	"	O(5)/[1-O(5)]
Q_6	" " 10th " "	"	O(6)/[1-O(6)]
Q_7	" " 11th " "	"	O(7)/[1-O(7)]
Q_8	Reading " " " "	"	O(8)/[1-O(8)]
Q_9	Writing " " " "	"	O(9)/[1-O(9)]

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		File/Var. Name	
C.	**Regents Graduation Exams**	A Transformed Var. As Defined Above	
Q_{10}	Regents English Exam - Above SRP		0(10)/[1-0(10)]
Q_{11}	" Math 10 " "	"	0(11)/[1-0(11)]
Q_{12}	" Biology " "	"	0(12)/[1-0(12)]
Q_{13}	" Chemistry " "	"	0(13)/[1-0(13)]
Q_{14}	" Social Studies "	"	0(14)/[1-0(14)]
D.	**Destination of High School Graduates**		
Q_{15}	Post Secondary 4 Years College	"	0(15)/[1-0(15)]
Q_{16}	Post Secondary 2 Years College	"	0(16)/[1-0(16)]
Q_{17}	Employment/Military	"	0(17)/[1-0(17)]
Q_{18}	Dropout	"	0(18)/[1-0(18)]
Q_{19}	Other	"	0(19)/[1-0(19)]

EXPLANATORY, FINANCIAL RESOURCE AND OTHER INPUT VARIABLES

A. Financial Resource Variables (Measured in dollar per pupil unit)

		MAKE 14 PROG OLD CODE		CORRES. VAR. IN DAVID'S AND/OR MAKE 14 (OLD) FILES
FRV_1	General Support Expenditures (less Chief School Adm. Aide)	Y_{51}	=	[X(134) - X(114)]/X(25)
FRV_2	Instructional Salaries - Chief School Admin.	Y_{52}	=	X(109)/X(25)
FRV_3	Instructional Salaries - Admin., Improvmnt. & Planning	Y_{57}	=	[X(135) + X(142) + X(149) + X(156)]/X(25)
FRV_4	Instructional Salaries - Teachers K-6	Y_{61}	=	X(163)/X(23)
FRV_5	Instructional Salaries - Teachers 7-12	Y_{62}	=	X(164)/X(24)
FRV_6	Equipment, Supply, Material, Textbooks	Y_{66}	=	[X(167) + X(169) + X(171)]/X(25)
FRV_7	Total Expenditure for PSEN per PSEN Pupil	Y_{68}	=	X(176)/[X(25) X (X(104)/100)]
FRV_8	Instructional Salaries - Media	Y_{69}	=	[X(177) + X(185)]/X(25)
FRV_9	Equipment, Supply, Material - Media	Y_{71}	=	[X(179) + X(181) + X(187) + X(189)]/X(25)
FRV_{10}	Instructional Salaries - Pupil Health, Psych. Soc. Ser.	Y_{74}	=	[X(194) + X(201) + X(208) + X(215)]/X(25)
FRV_{11}	Pupil Interschol. Athletic Ser. - Instruct. Salaries	Y_{79}	=	[X(222) + X(228)]/X(25)
FRV_{12}	Total Co-Curricular Interscholastic Athletics	Y_{83}	=	[X(227) + X(234)]/X(25) (Excl. from Model)
FRV_{13}	Total Pupil Transportation	Y_{86}	=	X(239)/X(25)
FRV_{14}	Community Service Instructional Salaries	Y_{87}	=	[X(240) + X(247) + X(225)]/X(25) (Excl. from Model)
FRV_{15}	Employee Benefits Total	Y_{92}	=	X(270)/X(25)
FRV_{16}	Sum of Selected Non-Instructional Salaries	Y_{118}	=	0(53) + 0(58) + 0(65) + 0(70) + 0(75) + 0(80) + 0(88)
FRV_{17}	Sum of Selected Expenditure on Equipment, Supply, Material	Y_{119}	=	0(54) + 0(59) + 0(76) + 0(81) + 0(89)
FRV_{18}	Sum of Selected Contractual, BOCES and Other Expenditures	Y_{120}	=	0(55) + 0(60) + 0(67) + 0(72) + C(77) + 0(82) + 0(91)
FRV_{19}	Average Teacher Salary Total (K-12)	Y_{140}	=	[X(163) + X(164) + X(165)]/[X(28) + 0.5 X(30)]
FRV_{20}	Sum of Selected Instructional Expenditures	Y_{141}	=	(0(64) + 0(69) + 0(87))

B. Teacher/School, Community and Pupil Attribution Indices

		FILE NAME OR MAKE 14 PROG. OLD CODE	CORRES. VAR. IN DAVID'S FILES
$TSCP_1$	No. of Book-Titles in the Library		X(99)/X(25)
$TSCP_2$	No. of Students Truant		X(100)
$TSCP_3$	Average Teacher Absence		X(101)
$TSCP_4$	% of Pupil Failed in 2 Subjects		X(102)
$TSCP_5$	% of Limited English Language		X(103)
$TSCP_6$	% of PSEN		X(104)
$TSCP_7$	Sq./ft. of Class Room per Pupil		[X(41)*770]/X(25)
$TSCP_8$	School/Teacher Characteristics Index[4]	DATA-SCHTCH (See Col. 3)	FS* [(0.5 TCHYRED) + TCHYREX]/[X_{28} + 0.5X_{30}]
COM_1	Real Value of Privately Owned Residential Property[1] denotes community attributes	C_{142} =	[[X(3) - X(4)]* X(5)]/X(23)
COM_2	Income per Return - denotes community attributes[2]	C_{117} =	X(322)
COM_3	Community Wealth Index[3]		WLTINDX = WLT2/[EFRT * AGE]
$PUPINX_1$	Index of 3rd grade attributes (a dummy variable; X_{32} = 1 iff probability of school is above county (or state) wide average; X_{32} = 0 otherwise)[3] time "t-3"		
$PUPINX_2$	Index of 6th grade attributes (a dummy variable; X_{33} = 1 iff probability of school is above county (or state) wide average performance; X_{33} = 0 time "t-3" otherwise)		
$PUPINX_3$	Index of 9th grade attributes (X_{34} = 1 iff probability of school is above county (or state) wide average performance; X_{34} = 0 otherwise) time "t-1"		
$PUPINX_4$	Index of 10th grade attributes (X_{35} = 1 iff probability of school is above county (or state) wide average; X_{35} = 0 otherwise) time "t-1"		
$PUPINX_5$	Index of 11th grade attributes (X_{36} = 1 iff probability of school is above county (or state) wide average; X_{36} = 0 otherwise) time "t-1"		

C. Alternative Variables

$ALTVAR_1$	Alternative school/teacher characteristics		[(0.5 TCHYRED) + THYREX]/[X_{28} + 0.5X_{30}] X_{25}

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[1] Derived from census data variables X(3), X(4), X(5) can be found in SATADATA file

[2] Measured in terms of $ per income tax returns

[3] Community wealth index variable   is derived as follows;

Let;

ASST = [X(3) - X(4)]* X(5); SATADATA file
WLT2 = INC1 + INC2 + ½* ASST; U 13 File
TXPB = X(318) * ASST;(X(318) is in David's file)
EFRT = TXPB/WLT2

Then Community Wealth (WLTINDX);

as defined in Appendix B

Where; (*) = Multiplication Symbol

[4] School/Teacher Characteristics Index is derived as a ratio of:

[1/2 years of teacher's ed. + years of teacher exp.]/pupils per te

Data can be found in:

File Name	Variable Code
DATA-TCH-DEG	Tchyred (col. 12)
DATA-TCHEXP	Tchyrex (col. 1)
DATA-F-S-6GN	FS = Field & Subject

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APPENDIX D

EXPLANATORY VARIABLES INCLUDED IN EACH EQUATION OF THE MODEL

Q_1 - Reading 3rd Grade Equation

Var. No.	Var. Code	Def. of Explanatory Var.
X1	FRV2	Instructional Sal. - Chief School Admin.
X2	FRV3	Instructional Sal. - Admin., Impr. & Pl.
X3	FRV4	Instructional Sal. - Teachers 7-12
X10	FRV20	Other Instructional Expenditures
X12	FRV22	Computer Service/Ed. T.V. Total
X13	FRV24	Co-Curricular Total
X16	FRV27	BOCES Adm./Plan/Impr. Expenditure
X24	FRV48	
X27	FRV52	Non-Inst. Sal. - Pupil & Comm. Services
X28	TSCP1	No. of Book Titles in the Library

Q_2 - Math 3rd Grade Equation

Var. No.	Var. Code	Def. of Explanatory Var.
X1	FRV2	Instructional Sal. - Chief School Admin.
X2	FRV3	Instructional Sal. - Admin., Impr. & Pl.
X3	FRV4	Instructional Sal. - Teachers 7-12
X10	FRV20	Other Instructional Expenditures
X12	FRV22	Computer Service/Ed. T.V. Total
X13	FRV24	Co-Curricular Total
X16	FRV27	BOCES Adm./Plan/Impr. Expenditure
X29	TSCP2	School Size Index
X34	APMX1	3rd Gr. Pupil Perf. Index Time "t-1"

Var. No.	Var. Code	Def. of Explanatory Var.
X8	FRV14	Community/Youth Serv. - Instr. Salaries
X9	FRV19	Average Teacher Salary Total (K-12)
X13	FRV24	Co-Curricular Total
X17	FRV28	BOCES/Inst. Teaching
X26	FRV51	Non-Inst. Sal. - Adm./Pln./Impr./Teaching
X35	APMX2	6th Gr. Pupil Perf. Index Time "t-1"

Q_4 - Math 6th Grade Equation

Var. No.	Var. Code	Def. of Explanatory Var.
X2	FRV3	Instr. Sal. - Admin., Impr., Planning
X3	FRV4	Instr. Sal. - Teachers K-6
X13	FRV24	Co-Curricular Total
X17	FRV28	BOCES - Inst. Teaching
X20	FRV32	Contractual - Inst. Teaching and Tuition
X28	TSCP1	No. of Book Titles in the Library
X29	TSCP2	School Size Index
X35	APMX2	6th Gr. Pupil Perf. Index Time "t-1"

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Q_5 - Math 9th Grade Equation

Var. No.	Var. Code	Def. of Explanatory Var.
X4	FRV5	Inst. Sal. - Teachers 7-12
X5	FRV7	Total Exp. for PSEN per PSEN Pupil
X19	FRV31	Contractual - Adm./Plan./Impr.
X20	FRV32	Contractual - Inst. Teaching and Tuition
X30	TSCP7	Sq./ft. of Classroom per Pupil - Crowdedness Index
X33	COM3	Community Wealth Index
X36	APMX3	9th Gr. Math RCT Index Time "t-1"

Q_6 - Math 10th Grade Equation

Var. No.	Var. Code	Def. of Explanatory Var.
X9	FRV19	Average Teacher Sal. Total (K-12)
X10	FRV20	Other Instr. Expenditures
X15	FRV26	Pupil Transport. & Maint. Total (Overhead)
X20	FRV32	Contractual - Inst. Teaching and Tuition
X23	FRV47	
X27	FRV52	Non-Inst. Sal. - Pupil & Comm. Services
X31	TSCP8	School Teacher Characteristics Index

Q_7 - Math 11th Grade Equation

Var. No.	Var. Code	Def. of Explanatory Var.
X1	FRV2	Instructional Sal. - Chief School Admin.
X2	FRV3	Instructional Sal. - Adm., Impr. & Pl.
X18	FRV29	BOCES - Pupil & Comm. Services
X30	TSCP7	Sq./ft. of Classroom per Pupil - Crowdedness Index

Q_8 - Reading 11th Grade Equation

Var. No.	Var. Code	Def. of Explanatory Var.
X4	FRV5	Instructional Salaries - Teachers 7-12
X9	FRV19	Average Teacher Salary Total
X24	FRV48	
X27	FRV52	Non-Inst. Sal. - Pupil & Comm. Services
X29	TSCP2	School Size Index
X30	TSCP7	Sq./ft. of Classroom per Pupil - Crowdedness Index
X33	COM3	Community Wealth Index

Q_9 - Writing 11th Grade Equation

Var. No.	Var. Code	Def. of Explanatory Var.
X1	FRV2	Instructional Sal. - Chief School Admin.
X4	FRV5	Instructional Sal. - Teachers 7-12
X6	FRV10	Instructional Sal - Pupil Health, Psych., Soc. Ser.
X14	FRV25	Gen. Support & Emply. Benefit (Overhead)
X17	FRV28	BOCES - Inst. Teaching
X21	FRV33	Contractual - Pupil & Comm. Services
X26	FRV51	Non-Inst. Sal. - Adm./Pln./Impr./Teaching

APPENDIX D, CONTINUED

Q_{10} - Regents English Exam Equation

Var. No.	Var. Code	Def. of Explanatory Var.
X4	FRV5	Instructional Sal. - Teachers 7-12
X10	FRV20	Other Instructional Expenditures
X14	FRV25	Gen. Support & Employee Benefit (Overhead)
X18	FRV29	BOCES - Pupil & Comm. Services
X38	APMX7	Regents English Pupil Perf. Index Time "t-1"

Q_{11} - Regents Math 10 Exam Equation

Var. No.	Var. Code	Def. of Explanatory Var.
X4	FRV5	Instructional Sal. - Teachers 7-12
X9	FRV19	Av. Teacher Sal. Total (K-12)
X10	FRV20	Other Instructional Expenditures
X20	FRV32	Contractual - Inst. Teaching and Tuition
X28	TSCP1	No. of Book Titles in Library
X37	AOMX6	10th Gr. Math Pupil Perf. Index Time "t-1"

Q_{12} - Regents Biology Exam Equation

Var. No.	Var. Code	Def. of Explanatory Var.
X4	FRV5	Instructional Sal. - Teachers 7-12
X10	FRV20	Other Instructional Expenditures
X11	FRV21	School Library Total
X33	COM3	Community Wealth Index
X40	APMX9	Regents Biology Pupil Perf. Index Time "t-1"

Q_{13} - Regents Chemistry Exam Equation

Var. No.	Var. Code	Def. of Explanatory Var.
X1	FRV2	Instructional Sal. - Chief School Admin.
X4	FRV5	Instructional Sal. - Teachers 7-12
X9	FRV19	Av. Teacher Sal. Total (K-12)
X10	FRV20	Other Instructional Expenditures
X21	FRV33	Contractual - Pupil & Comm. Services
X25	FRV49	
X29	TSCP2	School Size Index
X30	TSCP7	Sq./ft. of Classroom per Pupil - Crowdedness Index

Q_{17} - Employment/Military

Var. No.	Var. Code	Def. of Explanatory Var.
X2	FRV3	Instructional Sal. - Admin., Impr. & Planning
X13	FRV26	Co-Curricular Total
X17	FRV28	BOCES - Inst. Teaching
[illegible]	FRV48	
[illegible]	TSCP8	School Teacher Characteristics Index
X32	COM2	Income per Return - denotes comm. attributes

Q_{14} - Regents Social Studies Exam Equation

Var. No.	Var. Code	Def. of Explanatory Var.
X4	FRV5	Instructional Sal. - Teachers 7-12
X5	FRV7	Total Exp. for PSEN per PSEN Pupil
X9	FRV19	Av. Teacher Sal. Total (K-12)
X10	FRV20	Other Instructional Expenditures
X14	FRV25	Gen. Support & Emply. Benefit (Overhead)
X21	FRV33	Contractual - Pupil & Comm. Services
X23	FRV47	
X24	FRV48	
X26	FRV51	Non-Inst. Sal. - Adm./Pln./Impr./Teaching
X29	TSCP2	School Size Index
X38	APMX7	Regents English Exam Pupil Perf. Index Time "t-1"

Q_{15} - Post Secondary 4-Year College

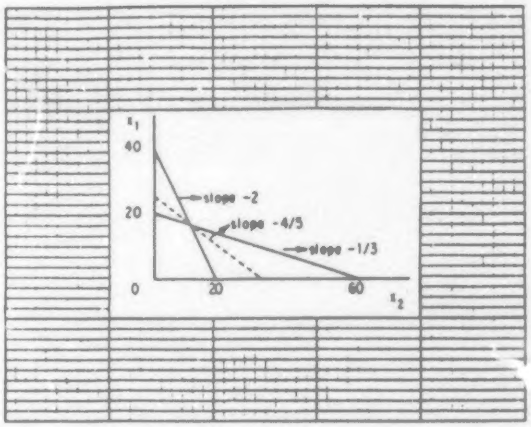
Var. No.	Var. Code	Def. of Explanatory Var.
X2	FRV3	Instructional Sal. - Admin., Impr., & Planning
X4	FRV5	Instructional Sal. - Teachers 7-12
X6	FRV10	Instructional Sal. - Pup. Health, Psych.,Soc.Ser.
X7	FRV12	Total Interscholastic Athletics
X13	FRV24	Co-Curricular Total
X17	FRV28	BOCES - Inst. Teaching
X24	FRV48	
X33	COM3	Community Wealth Index

Q_{16} - Post Secondary 2-Year College

Var. No.	Var. Code	Def. of Explanatory Var.
X4	FRV5	Instructional Sal.
X8	FRV14	Comm./Youth Ser. - Instructional Sal.
X10	FRV20	Other Instructional Expenditures
X23	FRV47	
X25	FRV49	
X31	TSCP8	School Teacher Characteristics Index
X33	COM3	Community Wealth Index
X39	APMX8	RIgents Math 10 Pupil Perf. Index Time "t-1"

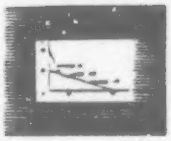
Q18 - Dropout

Var. No.	Var. Code	Def. of Explanatory Var.
X1	FRV2	Instructional Sal. - Chief School Admin.
X8	FRV14	Comm./Youth Serv. - Instructional Sal.
X9	FRV19	Average Teacher Salary Total (K-12)
X13	FRV26	Co-Curricular Total
X22	FRV36	
X38	APMX7	Regents English Pupil Perf. Index Time "t-1"



CHAPTER III.

FINANCIAL RESOURCE ALLOCATION PROCEDURE FOR ACHIEVING PUPIL PERFORMANCE TARGETS: A GOAL PROGRAMMING APPROACH



FINANCIAL RESOURCE ALLOCATION PROCEDURE FOR ACHIEVING PUPIL PERFORMANCE TARGETS: A GOAL PROGRAMMING APPROACH ‡

I. INTRODUCTION

In 1981, $10.08 billion dollars were spent on the education of 2.83 million pupils enrolled in 737 school systems (districts) of the State of New York [N.Y. State Comptroller, 1981].* During that year the total expenditure incurred by local governments of the State of New York amounted to $27.6 billion, while the total state personal income amounted to $201.8 billion [N.Y.S. Dept. of Commerce, Bureau of Economic Analysis, 1981]. Thus, approximately 5% of the personal income originated in the public education sector, and 36.5% of the local government expenditure were devoted to education. On Long Island the percentage of local government expenditure devoted to education was even higher; it amounted to 51% and 42% of local government expenditure of Suffolk and Nassau Counties, respectively. While the provision of educational services to the children can be justified in principle on legal grounds, the accountability of expenditures for such services can be enhanced through the utilization of management science techniques. However, it had become evident earlier in the project that the educational sector barely examined the problem of efficacious utilization of financial resources. The lack of attention to this problem can be attributed to a prevailing view threaded through various reports.

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*Authors and sources cited can be found in the bibliography.

‡This chapter is an edited copy of an earlier Working Paper (No. 12) with the same title by Spotthein/Wilson (May 1984).

Although the expenditure of monies is being audited by the State of N.Y. the prevailing notion is that accounting practices do not serve to evaluate the effectiveness of these expenditures [see Wohlfred, 1970]. Apparently this notion is shared by a recently created commission in New York State whose recommendations barely address the efficacious utilization of financial resources [Rubin, 1982], and the same can be said about the recommendations of national commissions. The collective view of these commissions is that the education sector can be more effective through the implementation of stiffer educational standards and graduation requirements [see N.Y. Times, Nov. 13, 1983; Wall Street Journal, April 26, 1984].

This view, however, can be challenged because the educational economics literature contains accepted theories and quantitative techniques that can be applied to the efficacious utilization of resource problems. The central theme of this body of literature is that the "need" to spend more money on specific programs (or functions) is unwarranted, unless it can be shown that such programs (or functions) are more effective than others [see Cohn/Millman, 1975; Fox, 1972]. The content of this paper is an extension of this body of literature; hence, the paper focuses on the application of economics and operations research methods to the efficacious resource allocation problems not addressed by the various commissions.

A. The Problem

Granted the egalitarian educational philosophy in the State of New York, and the commission's recommendations, the resource allocation problem within a school district can be stated as a policy predicament. Thus, the contents of this paper evolve around this major policy predicament, namely:

- What is the best composition of financial resources (by function) that would lead to a situation whereby a given type of school district would "produce" predetermined level of educational ends, while considering its pupils (and community) attributes.

While a resolution of this predicament may be perceived by some to be a formidable task, it is not. Although the educational economics literature is dominated by issues concerning the proper specification and calibration of educational production function models [see Chang, 1980; Thomas, 1962; Wendling/Cohen, 1981], few scholars have developed quantitative approaches for simulating such a policy predicament [see Fox, 1972; Sengupta/Fox,(1971) cited in Morgan, 1977]. These approaches are based on the reconciliation of operations research and econometric techniques.

B. The Approach

The central theme of this approach is that the mixed financial resources (by educational function, i.e., instructional salaries, equipment supply, material) could be adjusted so as to approach the "production possibilities frontier" with respect to predetermined educational goals (or targets). Hence, the composition of financial resources needed to realize these goals is determined in this paper through the application of a "goal programming" technique in conjunction with a recently developed "pupil performance model" [Spottheim/Libassi, 1984]. This amalgamation of techniques is an accepted methodology in the field of management science in general, and educational finance in particular. Cohn/Morgan (1977) and Fox (1972) have suggested this approach, while Morgan (1977) demonstrated its applicability to educational resource allocation problems.

To demonstrate the applicability of this approach (with respect to the predicament mentioned above), a few scenarios were formulated and solutions for various types of school districts (i.e., low, high "wealth") were simulated. The remainder of this paper is structured as follows: A survey of goal programming concepts and applications is presented in Section II whereas a goal programming model for Long Island school systems is presented in Section III. The improvement of the resource allocation procedure is discussed in Section IV, while the summary of this endeavor can be found in Chapter V.

II. GOAL PROGRAMMING CONCEPTS AND APPLICATION

It has been argued in the management science literature that there is no single goal which is ubiquitous to all organizations: rather organizations have multiple and conflicting goals. Because of this situation, organizational decision-makers continuously face a predicament of attaining a set of goals to the fullest possible extent in an environment of conflicting interests, limited resources, incomplete information, and knowledge concerning the complexity of their operational environment [Lee, 1972]. Consequently, scholars such as Charnes and Cooper (1961) have developed the "goal programming" technique to handle such decision-making environments [see Charnes and Cooper, cited in Lee, 1972, p. 35]. Since its development the technique was used by a variety of fields to determine solutions for a pre-specified set of complex and conflicting objectives of various types of organizations. In other words, goal programming, as noted by Lee (cited in Morgan, 1977), was used for the attainment of a "satisficing" solution which is subject to varying inputs and prioritized goals. This method could handle variables measured in terms of non-homogeneous units (i.e., money, pupils, teachers, etc.); therefore, it was widely applied to the resource allocation problems of non-profit and "nonmarket" institutions in general, and educational systems in particular [Lee, 1972; Morgan, 1977; Cohn _et al._, 1980]. In this paper, the varying input requirements were established by a recently developed production function model [Spottheim/Libassi, March 1984]. The prioritized educational goals, on the other hand, were established through consultation with educators.

A. Application of Goal Programming

Since its inception by Charnes and Cooper (1961) the goal programming technique was applied to a host of problems in various areas. Ijiri(1965) has used this technique for accounting control, whereas Lee (1972) applied this technique to problems concerning production planning, financial decisions and academic planning. Kendall and Lee (1980), on the other hand, have applied this technique to simulate medical care policies, while Bres and others (1980) have used it in military manpower planning. Sharpe (1970) has used this technique in conjunction with descriptive statistics to carry out a portfolio analysis. The rationale behind his study is that investment decisions can be simulated while using information concerning expected return and standard deviation of the expected returns [Sharpe cited in Goicoechea, et al 1982].

Fox (1972) has suggested that this technique can be used to simulate higher education problems, whereas Cohn and Millman (1975) have argued that this technique can be used in conjunction with a regression model (portraying input/output relationships) to simulate the attainability of predetermined goals of a Pennsylvania education system. Morgan (1977), Cohn and Morgan (1977), and Cohn et al (1980) have demonstrated that such an amalgamated approach can be applied to resource allocation problems within school districts. Spottheim/Wilson (1983), on the other hand, have used nonlinear goal programming techniques in conjunction with a "logistic" model to estimate the financial resources needed to realize a set of predetermined and prioritized educational targets. Finally, Bessent et al (1982) have recently applied mathematical programming to assess the "productivity" of schools located in Houston, Texas [Bessent, et al, Mgmt. Sc. Vol 28, No. 1[illegible] Dec. 1982], and Sherman (1981) used the same technique to measure the efficiency of hospital operations [see Sherman (1981) cited in Bessent et al, 1982].

B. An Illustration Goal Programming Formulation

The Goal Programming technique, as was noted earlier, is applicable in a situation where decisions are characterized by multiple objectives. The technique provides a solution which minimizes the sum of deviations from the prescribed set of preemptive target values (goals). Conventionally, goals are defined by the field of management science as "desired" outcomes which are operational (i.e., measurable). To simulate the attainability of these goals through the application of an amalgamation goal programming and econometric techniques, specific information concerning the system is required:

- formulas (or models) denoting the technical relationships between resources and outputs of the system in question
- preemptive values of target (or goals) variables
- upper and lower bounds of input (resource) variables
- prioritized specification of targets (goals) and their corresponding weights

Such information is then incorporated into the goal programming statement and upon execution of the technique, the following information is obtained:

- estimated value of the output (target) variables that could be achieved
- estimated value of corresponding resources (inputs) needed to produce the estimated outputs (or targets)
- indices denoting the achievement functions

The concepts of the foregoing discussion are expressed mathematically below. Characteristic of this expression is that it contains a formal (i.e., mathematical) notation concerning objective functions, constraints, and deviational variables. Notice that (unlike linear programming) the objective function in this technique is always specified as a minimization statement. The formulation of a problem could be functionally stated in Ignizio (1982) goal programming notation:

1. Minimize; $\bar{a} = [g_1 \ (\bar{d}^+, \bar{d}^-), \ . \ . \ . \ . \ , g_n \ (\bar{d}^+ , \bar{d}^-) \ ]$

   Subject to the following conditions

2. $f_i \ (\bar{F}, \bar{C}) \quad - d_i^+ \ + d_i^- \ = G_i, \ i \ = 1, \ 2, \ . \ . \ . \ ., \ n$

   In our case the outcomes, $Q_i \ = f_i; \ i = 1,2,...18$

   Where,

   d_i^+ = a "positive" deviational variable associated with the ith goal. This variable designates the amount by which the ith goal is exceeded.

   d_i^- = a "negative" deviational variable associated with the ith goal. This variable designates the amount by which f_i is less than the ith goal.

   $\bar{d}^+$ = a vector with elements d_i^+

   $\bar{d}^-$ = a vector with elements d_i^-

   $g_i \quad (\bar{d}^+, \bar{d}^-)$ = a linear relation of deviational variables evaluated at priority level i, where the g_i is a functional notation

   $\bar{F}$ = a vector with elements F_i - - i.e., in our case it could denote(financial) variables

   $\bar{C}$ = a vector with elements C_i - - i.e., community variables beyond the control of the district.

   $\bar{Q}$ = a vector with elements Q_i - - i.e., output (or outcome) variables (in our instance $Q_i \ = f_i \ , \ i = 1, \ 2 \ . \ . \ . \ 18)$

The assumptions and restrictions of the model imply that there can not be a negative resource (input) and the "deviational variables" (d_i^-, d_i^+) cannot be negative. Thus, the notation d_i^-, for example, refers to an "underachievement" variable when it is desired that goal i be equalled or exceeded, whose magnitude is not less than zero. Symbolically this statement can be expressed as follows:

$$F_1, F_2, \ldots\ldots, F_n \geq 0$$

$$d_1^+, \; d_1^-, \; d_2^+, \; d_2^-, \; \ldots\ldots, \; d_n^+ \geq 0$$

Goal programming technique can handle complex and conflicting objectives, (i.e., targets or goals), whereas a linear programming technique requires a single objective function. The former method, however, presupposes that school administrators, for example, can rank specific targets (goals), hierarchically, thereby allowing this technique to search for a "satisficing" (rather than optimizing) solution concerning the mix of required resources to ascertain the prioritized goals or targets. If an exact financial resource (inputs) mix is impossible to obtain, this method would provide a solution which minimizes the sum of the deviations from the prespecified educational targets. It would also determine the amount and mix of resources needed to realize these prioritized goals. Finally, should the priority of the educational targets be reordered, the technique would provide information concerning the resources needed to realize such targets.

In sum, while this technique has few limitations [see Lee, 1972], its advantages lie in its simulation capability; therefore it could be used for simulation governmental activities such as:

- management activities
- resource allocation for various functions

III. A GOAL PROGRAMMING MODEL FOR LONG ISLAND SCHOOL SYSTEMS

The resource allocation procedure presented hereafter was developed through a fruitful rapproachement of the "pupil performance model" (Spottheim/Libassi, March 1984) and the goal programming technique. In other words, the estimated coefficients of the pupil performance model were used as the "constants" of the goal programming model. Since this pupil performance model was calibrated while using a particular set of Long Island school districts, it captures in essence the "idealized" relationships between educational expenditures and outcomes of an "abstract" district. By using this amalgamated approach the issue whether these relationships (as denoted by the pupil performance model) reflect causality or merely correlation between educational means and ends was avoided. Because of this attribute this amalgamated approach is a useful tool for simulating challenges faced by the school district in general, and the attainment of educational goals with a discrete set of fixed financial resources, in particular.

A. Conceptual Educational Resource Allocation Process

Traditionally, this resource allocation (or simulation) procedure is executed without modifying the existing administrative structure and the decision processes. Therefore, "measurements" which summarize the prevailing educational reality must be identified, quantitatively. Specifically, goal programming model entails the execution of the following steps:

- estimation of the quantitative relationships between educational means and ends
- specification of prioritized educational targets (ends) of various types of districts as perceived by educational decision-makers
- determination of achievable level of goals and corresponding resources through simulation

Upon executing this approach, inferences concerning resource allocation policies can be drawn from the information generated by the goal programming, namely:

- recommendation concerning alternative course of actions,
- validation of the recommendations through implementation experimentation.

The foregoing discussion concerning the conceptual resource allocation process is presented schematically in Chart I. Notice that the prevailing administrative practices and the various steps have been "interfaced' in this chart.

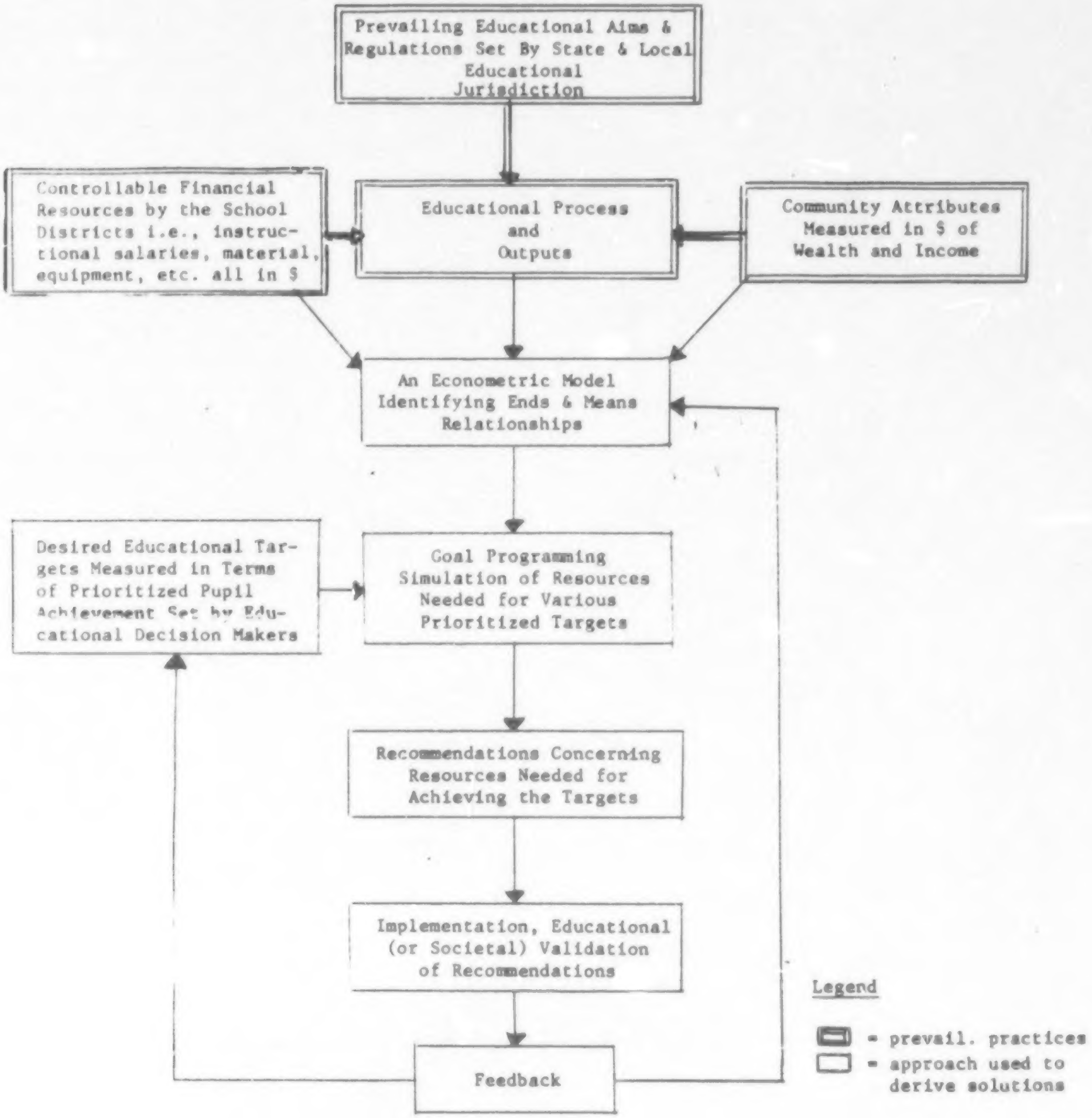
To test the applicability of this resource allocation procedure solutions for various scenarios were simulated. These scenarios reflect potential conditions that may be faced by various types of school districts. Hence, upon consultation with several school administrators it was decided to derive solutions for the following types of cases:

- a large school (case I)
- a district in transition (case II)
- selected types of districts within a given region (Case III)

The solutions for these cases were derived through the application of a linear goal programming in conjunction with the aforementioned pupil performance model [Spottheim/Libassi 1984]. The desired educational targets in this instance are said to be analogous to the dependent variables of that model.

CHART I

Schematic Representation of Resource Allocation Procedure


Prevailing Educational Aims & Regulations Set By State & Local Educational Jurisdiction
Controllable Financial Resources by the School Districts i.e., instructional salaries, material, equipment, etc. all in $
Educational Process and Outputs
Community Attributes Measured in $ of Wealth and Income
An Econometric Model Identifying Ends & Means Relationships
Desired Educational Targets Measured in Terms of Prioritized Pupil Achievement Set by Educational Decision Makers
Goal Programming Simulation of Resources Needed for Various Prioritized Targets
Recommendations Concerning Resources Needed for Achieving the Targets
Implementation, Educational (or Societal) Validation of Recommendations
Feedback
Legend
= prevail. practices
= approach used to derive solutions

The structure of each of the "transformed" logistic equations of that model as was noted elsewhere (see Spottheim/Libassi 1984) can be expressed as;

$$Q_{ij} = ln(O_{ij}/1-O_{ij}) = a_i + \sum_{k=1}^{K} b_k FRV_{k,j} + \sum_{l=1}^{L} c_l TSCP_{l,j} + \sum_{m=1}^{M} d_m COM_{m,j} + \sum_{n=1}^{N} e_n APNX_{n,j} + \hat{U}_{i,j}$$

Where;

Q_{ij} = transformed dependent variable concerning the "i^{th}" outcome and "j^{th}" school

ln = natural log symbol

$FRV_{k,j}$ = input or financial expenditure variable under the control of the school district - an explanatory varicble denoting expenditure (per pupil) by function "k" (i.e., salaries, expenditures on equipment, material, contractual, BOCES) of school district "j"

$TSCP_{l,j}$ = teacher or school characteristic index "l" - a nonfinancial explanatory variable observed in school district "j"

$COM_{m,j}$ = community index "m" - an explanatory variable denoting the socio-economic condition of school district "j"

$APNX_{n,j}$ = pupil performance index "n" (previous time period) observed in school district "j" - an explanatory variable

$\hat{U}_{i,j}$ = a residual (or error term) associated with the outcome "i" and school district "j"

a_i, b_k, c_l, d_m, e_n = estimated parameters (coefficients) associated with their respective explanatory variables - their values were determined (or calibrated) empirically, via ML techniques

Σ = summation symbol

Notice that the left hand side of this equation (i.e., dept. variable) is not a probability variable, rather it is a transformed variable. Such transformed logistic equations were used, because they lend themselves to the application of a regression technique for the purpose of estimating the unknown value of the coefficients of the 18 (logistic) equations of the model. Each equation is concerned with a particular educational outcome.

The application of the goal programming technique (to the resource allocation problem) espouses an a priori knowledge (by the districts) concerning the desired (educational) targets, community wealth and "pupil quality" indices, inasmuch as they were "pegged" before the application of this program. The value of other (financial) variables are computed by this technique.

The estimated coefficients then become the parameters of the goal programming problem. The various desired educational targets were specified in terms of the transformed (dept.) variables (Q_i) and the achievable targets were then "translated" into their respective probability variables (O_i). community (COM) and pupil quality (APNX) indices were then "pegged" (or bounded) at a predetermined value, thereby defining socio-economic attributes which may influence the outcomes, even though they are beyond the control of the school.

Finally, the intercepts, the negative coefficients and some of the explanatory (financial) variables (e.g., $x_3 - x_5$) were tempered with, because the goal programming technique called for positive parameters, zero intercepts and expenditures per total enrollment.[1] An elaboration of such manipulation is presented in the section that follows, where the variables, used in our amalgamted approach, are presented in Table 1 below.

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[1] Notice variables $x_3 - x_5$ are not per total enrollment (see Table I).

TABLE I

LIST OF VARIABLES USED TO CONSTRUCT THE MODEL

I. RAW DEPENDENT VARIABLES

A. Exam Results (Elementary School); Probability Measurements

Var. No.	
O_1	Reading Exam 3rd Grade - Above State Reference Point (SRP)
O_2	Math " " " " " " "
O_3	Reading Exam 6th Grade - " " " "
O_4	Math " " " " " " "

B. RCT Exam Results (Sec. Schools); Probability Measurements

O_5	Math Exam 9th Grade - Above SRP
O_6	" " 10th " " "
O_7	" " 11th " " "
O_8	Reading " " " " "
O_9	Writing " " " " "

C. Regents Graduation Exams; Probability Measurements

O_{10}	Regents English Exam - Above SRP
O_{11}	" Math 10 " " "
O_{12}	" Biology " " "
O_{13}	" Chemistry " " "
O_{14}	" Social Studies " "

D. Destination of High School Graduates; Probability Measurements

O_{15}	Post Secondary 4 Years College
O_{16}	Post Secondary 2 Years College
O_{17}	Employment/Military
O_{18}	Dropout
O_{19}	Other

II. TRANSFORMED DEPENDENT VARIABLES (LOGIT)

A. Exam Results (Elementary School)

Q_1	Reading Exam 3rd Grade - Above State Reference Point (SRP)	$\ln O(1)/[1-O(1)]$**
Q_2	Math " " " " " " "	$\ln O(2)/[1-O(2)]$
Q_3	Reading " 6th " " " " "	$\ln O(3)/[1-O(3)]$
Q_4	Math " " " " " " "	$\ln O(4)/[1-O(4)]$

B. RCT Exam Results (Sec. Schools)

Q_5	Math Exam 9th Grade - Above SRP	$\ln O(5)/[1-O(5)]$
Q_6	" " 10th " " "	$\ln O(6)/[1-O(6)]$
Q_7	" " 11th " " "	$\ln O(7)/[1-O(7)]$
Q_8	Reading " " " " "	$\ln O(8)/[1-O(8)]$
Q_9	Writing " " " " "	$\ln O(9)/[1-O(9)]$

**ln = A symbol denoting natural log.

C. Regents Graduation Exams

Q_{10}	Regents English Exam - Above SRP	$\ln O(10)/[1-O(10)]$
Q_{11}	" Math 10 " " "	$\ln O(11)/[1-O(11)]$
Q_{12}	" Biology " " "	$\ln O(12)/[1-O(12)]$
Q_{13}	" Chemistry " " "	$\ln O(13)/]1-O(13)]$
Q_{14}	" Social Studies " " "	$\ln O(14)/[1-O(14)]$

D. Destination of High School Graduates

Q_{15}	Post Secondary 4 Years College	$\ln O(15)/[1-O(15)]$
Q_{16}	Post Secondary 2 Years College	$\ln O(16)/[1-O(16)]$
Q_{17}	Employment/Military	$\ln O(17)/[1-O(17)]$
Q_{18}	Dropout	$\ln O(18)/[1-O(18)]$

III. EXPLANATORY, FINANCIAL RESOURCE AND OTHER INPUT VARIABLES

A. Financial Resource Variables (Measured in dollar per pupil unit)

Var. No.	Var. Code	
X(1)	FRV2	Instructional Salaries - Chief School Admin.
X(2)	FRV3	Instructional Salaries - Admin., Improvmnt. & Planning
X(3)	FRV4	Instructional Salaries of Teachers K-6 per grade K-6 enrollment
X(4)	FRV5	Instructional Salaries - Teachers 7-12 per grade 7-12 enrollment
X(5)	FRV7	Total Expenditure for PSEN per PSEN Pupil†
X(6)	FRV10	Instructional Salaries - Pupil Health, Psych. Soc. Ser.
X(7)	FRV12	Total Interscholastic Athletics
X(8)	FRV14	Community/Youth Service-Instructional Salaries
X(9)	FRV19	Average Teacher Salary Total (K-12) (Not per pupil unit)
X(10)	FRV20	Other Instructional Expenditures (i.e. substitute teachers)
X(11)	FRV21	School Library Total
X(12)	FRV22	Computer Service/Ed. TV Total
X(13)	FRV24	Co-Curricular Total
X(14)	FRV25	General Support & Empl Benefit (overhead)
X(15)	FRV26	Pupil Transport. & Maintain. Total (overhead)
		BOCES
X(16)	FRV27	BOCES-Adm/Plan/Improvement Expenditure
X(17)	FRV28	BOCES-Inst. Teaching
X(18)	FRV29	BOCES-Pupil & Comm. Services
		CONTRACTUAL (& TUITION)
X(19)	FRV31	Contractual-Adm/Plan/Improvement
X(20)	FRV32	Contractual-Inst. Teaching and Tuition
X(21)	FRV33	Contractual-Pupil & Comm. Services
		BOCES & CONTRACTUAL
X(22)	FRV36	Instructional-BOCES & Contractual (FRV28 + FRV32)

SUPPLY MATERIAL, TEXTBOOK & EQUIPMENT

X(23)	FRV47	Admin/Plan/Improvement (FRV39 + FRV43)
X(24)	FRV48	Instructional teaching (FRV40 + FRV44)
X(25)	FRV49	Pupil and Community Services (FRV41 + FRV45)

NON-INSTRUCTIONAL SALARIES

X(26)	FRV51	Non-Inst. Sal.-Adm/Pln/Improvement/Teaching
X(27)	FRV52	Non-Inst. Sal.-Pupil & Comm. Services

B. Teacher/School, Community and Pupil Attributes Indices

X(28)	TSCP1	No. of Book-Titles in the Library
X(29)	TSCP2	School Size Index (1 if more than 4800 pupils; 0 Otherwise)
X(30)	TSCP7	Sq./ft. of Class Room per Pupil-a crowdedness index
X(31)	TSCP8	School Teacher Characteristics Index
X(32)	COM2	Income per Return - denotes community attributes
X(33)	COM3	Community Wealth Index

C. Pupil Characteristics Previous Year

X(34)	APNX1	3rd grade pupil perf. index time "t-1"[++]
X(35)	APNX2	6th grade " " " " "
X(36)	APNX3	9th grade math RCT " " "
X(37)	APNX4	10th grade math RCT " " "
X(38)	APNX7	Regents English " " "
X(39)	APNX8	Regents Math 10 " " "
X(40)	APNX9	Regents Biology " " "

[+] PSEN is an acronym for pupils with special educational needs.

[++] Note $APNX_i$ are binary (dummy) variables.

B. The Goal Programming Model - General Description

Specific details of the goal programming model used to simulate the various scenarios will now be given. A total of 52 objectives and restrictions are included, each a function of a subset of the 40 explanatory variables which are denoted above in Table I (notice that Case I contains 56 objectives). The objectives can be grouped into 3 classes:

(1) Educational achievement objectives,

(2) Budgetary constraints and restrictions,

(3) "Bounding" and/or "pegging" of individual variables.

The target values (goals) for the educational objectives for various types of districts were determined by educators. Also. the intercept values, being constant, were subtracted from both sides of the objective equations. What results are the following:

Q_1: $- .00756X_1 - .01214X_2 + .00051X_3 - .0109X_{10} + .0344X_{12} + .0497X_{13} +$
$.1618X_{16} - .0129X_{24} - .0359X_{27} + .1132X_{28} + d_1^- - d_1^+ = -.56$

Q_2: $- .0066X_1 - .0105X_2 + .0013X_3 - .0122X_{10} + .0236X_{12} + .04X_{13}$
$+ .1259X_{16} - .2514X_{29} + .314X_{34} + d_2^- - d_2^+ = .4$

Q_3: $.0813X_8 + .00008X_9 + .0238X_{13} - .00404X_{17} - .00901X_{26}$ X $.5525X_{35}$
$+ d_3^- - d_3^+ = 1.44$

Q_4: $- .0067X_2 + .0011X_3 + .0286X_{13} - .0051X_{17} + .0168X_{20} - .0758X_{28}$
$- .3206X_{29} + .7141X_{35} + d_4^- - d_4^+ = -.17$

and so on. Refer to Table II, W.P. #8, (or the previous chapter of this report) for financial variable coefficients for the remaining 14 equations (objectives). A complete set of "transformed" goals is summarized below:

Objective, k	*1	2	3	*4	5	6	7	8	9	10	11	*12	13	*14	15	*16	*17	*18
$\bar{Q}_k - A_k$	-.56	.4	1.44	-.17	-4.04	.593	4.56	3.18	1.66	.17	.51	-.67	.46	-2.48	.39	-.86	-1.79	-1.85

Since the linear goal programming algorithm requires positive values for goals, the "starred" objectives (as summarized above) had to be multiplied by -1 (except for the deviational variables). Conventionally, objectives 1 through 17 should be increased to meet or exceed their respective goals and objective 18 (dropout) was to be decreased, whereas in our case "satisficing" is reversed for the starred objectives.

Objective 19, on the other hand, is a budget constraint having the following form:

$$\sum_{k=1}^{27} C_k X_k + d_{19}^- - d_{19}^+ = G_{19}$$

$(k \neq 9,22)$

Where;

$C_k =$ .55, $k = 3$ (proportion of students K-6)
.45, $k = 4$ (proportion of students 7-12)
.1, $k = 5$ (proportion of students under PSEN)
1.0, otherwise

In this study of selected districts, G_{19} (total expenditure per pupil) was made equal to the sum of the mean values of X_k as determined from the data, \$3506/pupil. Of course, the goal was to not exceed this value.

Objective 20 maintains a technical relationship among variables X_3, X_4, and X_9. It was imputed as follows:

Let T = total number of teachers, K-12
S = total number of students, K-12

then since $\overline{X}_9 =$ \$19781.75/teacher
$\overline{X}_3 =$ 1092.54/student K-6
$\overline{X}_4 =$ 1444.61/student 7-12

we have $(\overline{X}_9)\ (T) = (.55)\ (X_3)\ (S) + (.45)\ (X_4)\ (S)$

(19781.75/teacher) (#teachers) - (.55S in K-6) (1092.54/K-6 pupil)
+ (.45S in 7-12) (1444.61/7-12 pupil)

$$\text{Average student to teacher ratio} = \frac{S}{T} = \frac{19781.75}{(.55)\ (1092.54) + (.45)\ (1444.61)} = 15.81$$

which we assume, at this point, to be constant, for grades K-12.

Therefore, objective 20 is

$$8.7X_3 + 7.1X_4 - X_9 + d_{20}^{-} - d_{20}^{+} = 0,$$

and the goal is to maintain equality.

Objective 21 is another technical relationship. X_{22} is simply the sum of X_{17} and X_{20}. Therefore,

$$X_{17} + X_{20} - X_{22} + d_{21}^{-} - d_{21}^{+} = 0,$$

and the goal is to maintain equality.

Objectives 22 through 39 maintain lower bounds on financial variables associated with activities that may not be eliminated. Therefore, a "threshold" amount of expenditure/student is required to establish viable conduct of that activity and the lowest value found for some school district in the data set is used as the threshold for each such financial variable. The objectives have the form

$$X_k + d_i^{-} - d_i^{+} = G_i \qquad i = 22, 23, \ldots, 39$$

$$k = 1\text{-}7, 10, 11, 13\text{-}15, 17, 20, 21, 24, 26, 27$$

and the goal is to meet or exceed the threshold value, G_i. For k = 14 and 15, G_{32} and G_{33} are set to the lower bounds for those variables (overhead costs), and the goal is to maintain equality.

Objectives 40 through 52 established upper bounds on certain "indicator" variables that could be changed for the sake of scenario construction. These objectives have the form

$$X_k + d_i^{-} - d_i^{+} = G_i \qquad i = 40, \ldots, 52; k = 28, 29, \ldots, 40$$

Case I, on the other hand, contains additional objectives such as;

Obj. 53; $X_9 \geq 16677$
Obj. 54; $X_{28} \geq 5.76$
Obj. 55; $X_{30} \geq 20.44$
Obj. 56; $X_{31} \geq 31.7$

C. The Scenarios and the Simulation Results

As was noted earlier, the goal programming technique was used (in conjunction with the pupil performance model) to estimate the achievable level of the predetermined educational targets and the corresponding financial resources for various types of school district. The results presented henceforth are based on the premise that four major attributes influence the educational outcomes;

- Input or financial resources
- Teachers and/or school characteristics
- Community wealth
- Quality of pupils

The first and second attributes are "educational factors of production" controlled by the schools, whereas the remainder are said to be beyond their control, and as such, they cannot be "manipulated" by the school systems. It was assumed that the various types of school district can be "classified" in terms of pupil and community attributes which are beyond the control of the districts.

Hence, several explanatory variables (of the pupil performance model) were "pegged" at a given value. The community attribute (X_{33}), for instance, was fixed at one of three values reflecting low, average or high community wealth index, whereas the school size index X_{29} is a binary variable denoting whether the school district enrollment is greater or less than 4800 pupils. On the other hand, the seven pupil characteristics (X_{34}-X_{40}) are dichotomous variables which were set at specific values. They denote whether the pupils (enrolled in a given district) performed (in a previous year) above, or below county average (or at the county average level). These variables were chosen inasmuch as they depict the community "contribution" to the educational process and the "quality of pupils" of a district, respectively. Since they do influence the outcomes (and resource requirement) these variables were used to define the socioeconomic educational environment of the following types of cases;

- a large school district (Case I)
- a district in transition (Case II)
- various types of districts within a given region (Case III)

The goals, the desired target (outcome) values ($0_1 - 0_{18}$) and several indices reflecting the community and pupil attributes (which are beyond the control of the schools; $X_{32} - X_{40}$) all were determined in collaboration with school administrators for each of the cases. Overhead (financial) variables ($X_{14} - X_{15}$) were also fixed, while simulating the solutions for these cases. Alternative scenarios for each case were then formulated and simulated. For instance, in simulation solutions for case I - a large school district - two alternative scenarios were formulated for two alternative budget configurations for each, (i.e., \$3506 per pupil and \$3150 per pupil). The scenarios in this case are reflected in terms of alternative priority classes for the outcomes - they are as follows:

	Priority Classes	
Outcome Code	Scenario 1	Scenario 2
$0_1 - 0_4$	2	2
$0_5 - 0_7$	3	4
$0_8 - 0_9$	4	5
$0_{10} - 0_{14}$	5	3
$0_{15} - 0_{16}$	6	6
$0_{17} - 0_{18}$	7	7

Case II - a school district in transition on the other hand, contains solutions for three different scenarios and two budget configurations for each scenario. The same can be said for Case III. Finally, seven prioritized goals were specified for all cases and their respective scenarios. In all cases, the first priority concerned the budget constraints, while the remainder dealt with the desired educational targets.

a. *Case I - A Large School District*

The application of the goal programming technique to the resource allocation problem of a large school district will now be presented. This case as was noted earlier, contains two alternative scenarios. In both scenarios there are seven priority classes. The first priority concerned the budget constraints, whereas the remainder deal with the educational (outcomes) targets. These desired outcomes (as was noted earlier) were defined as "transformed" probability. The school in question is characterized by having the following school community and pupil attributes during the 1979-80 school year:

Variable Code		Value
X_{29}	$TSCP_2$	1
X_{32}	COM_2	\$15,000
X_{33}	COM_3	\$50,000
X_{34}	$APNX_1$	0
X_{35}	$APNX_2$	.5
X_{36}	$APNX_3$	.5
X_{37}	$APNX_4$	.5
X_{38}	$APNX_7$	0
X_{39}	$APNX_8$	0
X_{40}	$APNX_9$	.0

The desired target value ($0_1 - 0_{18}$) was provided by administrators of this school and several other variables were fixed at a predetermined value. Hence, the overhead variables (X_{14}, X_{15}) were fixed at $1120 and $530 respectively, and X_5 was fixed at $50. All other financial variables were determined by the goal programming technique. However, these variables were constrained by lower or upper bounds. The desired educational targets. priority for scenarios 1 and 2, weight and the bounds are all tabulated and summarized below in Table II.

The results of this endeavor are presented in Table III that follows.** It contains solutions for scenario 1 and scenario 2, and other relevant information. Hence this table contains 9 columns of information denoting.

1. Variable Code
2. Mean Value
3. Lower Bound
4. Upper Bound
5. Desired Target
6. Scenario I Solution (for a budget of $3506 per pupil)
7. Scenario I Solution (for a budget of $3150 per pupil)
8. Scenario II Solution (for a budget of $3506 per pupil)
9. Scenario II Solution (for a budget of $3150 per pupil)

**Notice solutions for financial variables (X_1-X_{27}) have been computed (and tabulated, henceforth) in constant (1980) dollars.

Table II
Case I: A Large School District

Educational outcome targets, priorities, and weights ("starred"* variable must be multiplied by -1)

Outcome O_i	Desired Target For O_i	"Transformed" Target $G_i = O_i - A_i$ 1	Priority Class of i		Deviational Variable Minimized	Weight Within Priority Class
			Scen.1	Scen.2		
1	.9	-1.323*	2	2	d^+	.2
2	.93	- .223*	2	2	d^+	.2
3	.85	2.125	2	2	d^-	.3
4	.88	.1424	2	2	d^-	.3
5	.75	-3.71 *	3	4	d^+	.5
6	.65	.622	3	4	d^-	.3
7	.5	4.37	3	4	d^-	.2
8	.9	4.237	4	5	d^-	.4
9	.75	2.379	4	5	d^-	.6
10	.9	1.097	5	3	d^-	.3
11	.75	.309	5	3	d^-	.2
12	.8	- .844*	5	3	d^+	.15
13	.85	.755	5	3	d^-	.15
14	.85	-2.515*	5	3	d^+	.2
15	.3	.083	6	6	d^-	.5
16	.3	- .727*	6	6	d^+	.5
17	.2	-2.286*	7	7	d^+	.6
18	.1	-2.367*	7	7	d^-	.4

Lower bound for financial variables or fixed value (indicated by a † symbol)

Variable X_i	Lower Bound	Objective 2
X_1	9.32	22
X_2	39.95	23
X_3	795.5	24
X_4	1083.	25
X_5	50. †	26
X_6	39.47	27
X_7	15.49	28
X_8	0	
X_9	16677	
X_{10}	16	29
X_{11}	15.9	30
X_{12}	0	
X_{13}	2.05	31
X_{14}	1120 †	32
X_{15}	530 †	33
X_{16}	0	
X_{17}	32.7	34
X_{18}	0	
X_{19}	0	
X_{20}	3.86	35
X_{21}	3.22	36
X_{22}	0	
X_{23}	0	
X_{24}	40.8	37
X_{25}	0	
X_{26}	31.72	38
X_{27}	9.3	39

Attribute variables have the following upper bounds or fixed value (indicated by a † symbol)

Variable X_i	Upper Bound	Objective 3
X_{28}	31.02	40
X_{29}	1.0 †	41
X_{30}	45.92	42
X_{31}	56.15	43
X_{32}	15000 †	44
X_{33}	50000 †	45
X_{34}	0 †	46
X_{35}	.5 †	47
X_{36}	.5 †	48
X_{37}	.5 †	49
X_{38}	0 †	50
X_{39}	0 †	51
X_{40}	0 †	52

The mean value of an outcome "O_i", for example, depicts the probability that an average school district (located on Long Island) will "produce" an outcome "i". The lower and upper bounds denote that probability for the upper and lower 20% of the districts respectively.

On the other hand, the mean value of an input variable "X_i" depict the expenditure (per pupil) of an average school district, whereas the lower and upper bounds of that variable depict that expenditure for the upper and lower 20% of the districts, respectively.

The solutions recorded in Table III indicate that the results for the two scenarios are similar. For instance, a comparison of the results of Scenario 1 (budget of $3506 per pupil) against those of Scenario 2, reveals that all desired education targets can be met (with a budget of $3506/pupil) even though the scenarios differ in their priority classes. On the other hand, a comparison of Scenario 1 results (with a budget of $3150 per pupil) against the results of Scenario 2 (as denoted in column 9) shows that certain targets cannot be met in both scenarios. In other words, the desired targets (regardless of their priority classes) can be realized providing the total school budget is at least $3506 per pupil. Hence a reduction of that budget is unwarranted for this school, because the "budget slack" is equal to zero, for both scenarios. In addition to the above, the distribution of such a budget over the various functions (i.e., variables X_1 - X_{27}), has some policy implications -- which are discussed below.

One way of examining the distribution of that budget ($3506/pupil)

Table III

Case I Simulation Results

1 Outcome Variable Code	2 Mean Value	3 Lower Bound Value	4 Upper Bound Value	5 Desired Ed. Target	6 Scenario 1 Solution $3506/Pupil ‡	7 Scenario 1 Solution $3150/Pupil ‡	8 Scenario 2 Solution $3506/Pupil ‡	9 Scenario 2 Solution $3150/Pupil ‡
O_1	.919	.8400	.9900	.90	.99	.99	.99	.99
O_2	.931	.7200	.9900	.93	.96	.99	.96	.99
O_3	.711	.2500	.9500	.85	.85	.85	.85	.85
O_4	.806	.4100	.9900	.88	.88	.88	.88	.88
O_5	.676	.3333	.9324	.75	.75	.75	.75	.75
O_6	.628	.3846	.9267	.65	.649	.640	.649	.640
O_7	.529	.2653	.9993	.50	.97	.98	.97	.98
O_8	.769	.1579	.9990	.90	.91	.890	.91	.890
O_9	.586	.2500	.8269	.75	.78	.75	.78	.75
O_{10}	.762	.3846	.9167	.90	.899	.82 *	.899	.82*
O_{11}	.763	.0588	.9608	.75	.80	.87	.80	.87
O_{12}	.810	.4091	.9990	.80	.799	.76 *	.799	.76*
O_{13}	.775	.1176	.9990	.85	.92	.97	.92	.97
O_{14}	.805	.2747	.9990	.85	.85	.92	.85	.92
O_{15}	.367	.1786	.8511	.30	.58	.51	.58	.44
O_{16}	.280	.1043	-286	.30	.30	.30	.30	.30
O_{17}	.313	.0266	.5190	.20	.20	.03 *	.20	.04
O_{18}	.180	.0068	.4786	.10	.08 #	.01 #	.08#	.03#

# indicates dropout (O_{18}) rate - below the desired target of .10

Input Variable Code/Name	Mean Value	Lower Bound Value [1]	Upper Bound Value [1]	Fixed Var.	SOLUTIONS FOR INPUT VARIABLES			
X_1 FRV_2	54.61	9.32	69.17		9	9	9	9
X_2 FRV_3	89.56	39.35	153.00		156	39	156	39
X_3 FRV_4	1092.56	795.56	1283.76		1396	1035	1396	1036
X_4 FRV_5	1444.61	1083.10	1593.55		1145	1085	1145	1089
X_5 FRV_7	50.72	5.22	120.00	50 †	(50)	(50)	(50)	(50)
X_6 FRV_{10}	70.01	39.47	145.00		39	39	39	39
X_7 FRV_{12}	36.05	15.49	55.69		15	15	15	15
X_8 FRV_{14}	.94	.01	10.00		0	0	0	0
X_9 FRV_{19}	19781.75	16677.56	24000.00		20535	16748	20535	15739
X_{10} FRV_{20}	31.17	15.94	100.00		16	16	16	16
X_{11} FRV_{21}	56.03	15.91	74.40		24	0	24	0
X_{12} FRV_{22}	3.17	.01	10.68		0	0	0	0
X_{13} FRV_{24}	9.68	2.05	17.07		22	37	22	34
X_{14} FRV_{23}	1120.82	860.45	1306.08		(1121)	(1121)	(1121)	(1121)
X_{15} FRV_{26}	530.88	409.45	800.00		[illegible]	(531)	(531)	(531)
X_{16} FRV_{27}	1.32	.01	20.00		[illegible]	0	0	0
X_{17} FRV_{28}	66.73	32.70	140.00		32	82	32	82
X_{18} FRV_{29}	1.20	.01	3.01		12	0	12	0
X_{19} FRV_{31}	5.35	.01	12.17		0	43	0	43
X_{20} FRV_{32}	17.16	3.86	50.00		92	6[illegible]	92	60
X_{21} FRV_{33}	8.63	3.22	16.51		3	3	3	3
X_{22} FRV_{36}	83.89	42.00	140.27		125	143	125	143
X_{23} FRV_{47}	3.93	.63	25.00		2	1	2	1
X_{24} FRV_{48}	69.77	40.80	120.00		40	40	40	40
X_{25} FRV_{49}	2.56	.91	8.00		0	0	0	0
X_{26} FRV_{51}	56.33	31.72	500.00		31	31	31	31
X_{27} FRV_{52}	21.23	9.30	34.15		9	9	9	9
X_{28} $TSCP_1$	15.08	5.76	31.02		31.0	31.0	31.0	31.0
X_{29} $TSCP_2$	.50	0	1.0	1†	(1.0)	(1.0)	(1.0)	(1.0)
X_{30} $TSCP_7$	27.93	20.44	45.92		35.3	41.0	35.3	41.1
X_{31} $TSCP_8$	43.45	31.70	56.15		31.7	31.7	31.7	31.7
X_{32} COM_2	18683.76	14669.40	22738.90	15000†	(15000.0)	(15000.0)	(15000.0)	(15000.0)
X_{33} COM_3	76716.81	44893.80	126186.00	50000†	(50000.0)	(50000.0)	(50000.0)	(50000.0)
X_{34} $APKE_1$	.6	0	1.0	0.0 †	0.0	0.0	0.0	0.0
X_{35} $APKE_2$	.5	0	1.0	0.5 †	0.5	0.5	0.5	0.5
X_{36} $APKE_3$	.5	0	1.0	0.5 †	0.5	0.5	0.5	0.5
X_{37} $APKE_4$	.5	0	1.0	0.5 †	0.5	0.5	0.5	0.5
X_{38} $APKE_7$	.6	0	1.0	0.0 †	0.0	0.0	0.0	0.0
X_{39} $APKE_8$	.6	0	1.0	0.0 †	0.0	0.0	0.0	0.0
X_{40} $APKE_9$	.6	0	1.0	0.0 †	0.0	0.0	0.0	0.0

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[1] 33 School Districts included (Fishers Island excluded). Upper bound is the mean of the upper 20% of S.D. Similarly, the lower bound is the mean of 20% of S.D.

‡ indicates budget slack = 0

* indicates objective (target) not met

( ) figure in parenthesis indicates fixed variable

† denotes variable fixed at the indicated value

# indicates dropout (O_{18}) rate exceeded the desired target of .10

NOTE: Budget constraint of $3506 per pupil implys:

$$\sum_{k=1}^{77} C_k X_k \le 3506 \; ; \; k \ne 9,22$$

Where:

C_k = .35, k = 3 (proportion of students K-6)
.65, k = 4 (proportion of students 7-12)
.1, k = 5 (proportion of students under PSEN)
1.0, otherwise

over the various education functions (i.e., input variables denoted in column 1, Table III) is to compare the money allocated by the goal programming technique, against the mean value of these functions (i.e., column 2, Table III). For instance, simulation technique allocated for functions X_1 - X_4 the following amount of money, 9, 156, 1396 and $1143 respectively (see col. 6), whereas the mean values of the same educational functions are; 54.61, 89.56, 1092.54, and $1444.44 respectively (see col. 2, Table III). In other words, the results of the simulation technique call for more financial resource to be allocated for functions; X_2 (adm. improvement and planning) and X_3 (instructional salaries K-6), whereas less money should be spent on functions X_1 and X_4. A decreased expenditure on X_4 implies that the pupil/teacher ratio (for high schools) can be increased without affecting the outcomes. Also notice that the result for X_{13} (co-curricular) is larger than the mean value of that function. This solution seems to confirm a New Jersey education study which showed a positive relationship between co-curricular expenditures and pupil performances. The simulation results also show that the average teacher salary (X_9) and expenditure on contractual teaching (X_{10}) should be increased to a level above their respective mean values, whereas the crowdedness (X_{31}) and teacher qualification (X_{32}) indices for that district (Case I) should have the values of 35.3 and 31.7 respectively (see col. 6, Table III). The increase in the average teacher salary seems to reinforce a N.Y. State School Board Assoc. policy position. [See Empire State Report Weekly (April 30, 1984)].

Although several educational targets cannot be realized with a budget of $3150 per pupil, the distribution of that budget over the various functions is warranted to be examined. For example, solutions generated for Scenario 1 with a total budget of $3150/pupil (see col. 7, Table III), revealed that more money should be allocated for functions; X_{13} (co-curricular)

X_{17} (BOCES inst. teaching) and X_{19} (contractual-adm./planning/improvement), whereas less money should be allocated for functions: X_2 - X_4, and X_9 (ave. teacher salary).

b. *Case II - A School District in Transition*

The budget requirements for a school district in transition were simulated through the application of our technique. To analyze this problem the Huntington Union Free School District was selected because its pupil performances, per pupil expenditures, community and pupil characteristics all resemble an "average" (or "abstract") Long Island district. Moreover, this district has gone through several stages of transition in the past 20 years. This transitional process may be intensified upon the completion of the high speed commuter rail to New York City.

Upon consultation with Dr. Charles Rudiger, School Superintendent, and Dr. Lester Dubnick and with the approval of the Board of Education of that district, it was decided to simulate the resource requirements for three scenarios which reflect alternative socio-economic environments that the school may face due to migration (of various population groups) that may be caused due to the new rail system. A socio-economic environment as was noted earlier, is defined in terms of (predetermined) pupil (X_{34}-X_{40}), school and community (X_{32},X_{33}) attributes which are beyond the control of the district. Hence, three scenarios (with two alternative budget configurations for each) were examined; Scenario 1 - low performing district, Scenario 2 - average district, and scenario 3 - high performing district. However, unlike the previous scanarios (see Case I) where such variables were fixed, in this case some variables were "bounded" on one side, that is these variables were allowed to vary in one direction. The idea behind this bounding procedure was to test whether the simulation procedure can generate the value of certain attributes which are beyond the control of the district. The scenarios of Case II were defined in terms of attributes (and/or variables) that were bounded (on one side) or pegged as follows:

Upper Bounds

Variable Code	Scenario I Low		Scenario 2 Average		Scenario 3 High	
X_5	$ 200	(Fixed)	$ 50	(Fixed)	5.2	(Fixed)
X_{28}	15	(LB)[3]	15.0	(MV)[2]	15	(UB)[1]
X_{29}	0	(LB)	.50	(MV)	1	(UB)
X_{30}	45.9	(LB)	45.9	(MV)	45.9	(UB)
X_{31}	31.7	(LB)	43.4	(MV)	56.1	(UB)
X_{32}	14,669	(LB)	18,668	(MV)	22,758	(UB)
X_{33}	44,893	(LB)	76,716	(MV)	126,186	(UB)
X_{34}	0	(LB)	.6	(MV)	1.0	(UB)
X_{35}	0	(Fixed)	.5	(MV)	1.0	(UB)
X_{36}	0	(Fixed)	.5	(MV)	1.0	(UB)
X_{37}	0	(Fixed)	.5	(MV)	1.0	(UB)
X_{38}	0	(Fixed)	.4	(MV)	1.0	(UB)
X_{39}	0	(Fixed)	.4	(MV)	1.0	(UB)
X_{40}	0	(Fixed)	.4	(MV	1.0	(UB)

The overhead variables (X_{14} and X_{15}) in Case II, were fixed at a value of $86[illegible].0 and $409.0 respectively. The common educational (outcomes) targets, priority and weight (for all three scenarios) were determined through consultation with Dr. L. Dubnick of the Huntington district. They are summarized below;

---

[1] (UB) denotes variable was bounded by an Upper Limit only.

[2] (MV) denotes variable was bounded by the Mean Value.

[3] (LB) denotes variable was bounded by a Lower Limit only.

Outcome O_i	Case II Targets For O_i	Transformed Target $G_i = Q_i - A_i$	Case II Priority	Deviation Variable Minimized	Weight
1	.969	- .08 *	2	d^+	.2
2	.931	- .21 *	2	d^+	.1
3	.811	1.847	2	d^-	.35
4	.956	1.23	2	d^-	.35
5	.774	-3.58 *	3	d^+	.4
6	.678	.748	3	d^-	.4
7	.54	4.46	3	d^-	.2
8	.949	4.96	4	d^-	.4
9	.786	2.58	4	d^-	.6
10	.862	.73	5	d^-	.3
11	.86	1.03	5	d^-	.15
12	.86	- .42 *	5	d^+	.15
13	.825	.57	5	d^-	.1
14	.825	-2.7 *	5	d^+	.3
15	.567	1.2	6	d^-	.7
16	.38	- .37 *	6	d^+	.3
17	.313	-1.69 *	7	d^+	.8
18	.08	-2.61 *	7	d^-	.2

NOTE: *Starred objectives (transformed targets) must be multiplied by -1 before adding deviation variables.

The results of the simulation effort are presented in Table IV that follows. Specifically, Table IV consists of 2 pages containing solutions for 3 scenarios (and two budget configurations for each scenario) along with other information, namely;

- Variable Code
- Mean Value
- Lower Bound
- Upper Bound
- Desired Target
- Scenario I Solution (for a budget of $3506 per pupil)
- Scenario I Solution (for a budget of $3150 per pupil)
- Scenario II Solution (for a budget of $3506 per pupil)
- Scenario II Solution (for a budget of $3150 per pupil)
- Scenario III Solution (for a budget of $3506 per pupil)
- Scenario III Solution (for a budget of $3150 per pupil)

Table IV
Case II - A School District in Transition Simulation Results
Huntington School District

1 Outcome Variable Code	2 Mean Value	3 Lower Bound Value	4 Upper Bound Value	5 Desired Ed. Target	6 Scenario 1 Solution $3506/Pupil‡	7 Scenario 1 Solution $3130/Pupil‡	8 Scenario 2 Solution $3506/Pupil‡	9 Scenario 2 Solution $3130/Pupil‡
O_1	.919	.8400	.9900	.969	.96	.96	.96	.96
O_2	.931	.7200	.9900	.931	.93	.93	.93	.93
O_3	.711	.2500	.9500	.811	.89	.81	.86	.86
O_4	.806	.4100	.9900	.956	.95	.95	.95	.95
O_5	.674	.3333	.9326	.776	.77	.77	.77	.77
O_6	.628	.3846	.9267	.678	.91	.67	.93	.93
O_7	.529	.2653	.9993	.56	.97	.98	.99	.99
O_8	.749	.1579	.9990	.969	.97	.96	.99	.96
O_9	.586	.2500	.8269	.706	.78	.78	.78	.78
O_{10}	.762	.3846	.9167	.862	.86	.76*	.86	.86
O_{11}	.763	.0588	.9808	.86	.86	.56*	.86	.86
O_{12}	.810	.4091	.9990	.86	.85	.76*	.85	.85
O_{13}	.775	.1176	.9990	.825	.82	.98	.98	.97
O_{14}	.805	.2747	.9990	.825	.91	.98	.82	.82
O_{15}	.367	.1786	.8511	.567	.56	.56*	.56	.56
O_{16}	.280	.1043	.4286	.38	.37	.18*	.37	.37
O_{17}	.313	.0266	.5190	.313	.16*	.0017*	.31	.31
O_{18}	.180	.0068	.4786	.08	.02	.0038	.02	.02

SOLUTIONS FOR INPUTS VARIABLES

Input Variable Code/Name	Mean Value	Lower Bound Value¹	Upper Bound Value ¹	Scenario 1 Solution $3506/Pupil‡	Scenario 1 Solution $3130/Pupil‡	Scenario 2 Solution $3506/Pupil‡	Scenarios 2 Solution $3130/Pupil‡
X_1 FRV_2	54.61	9.32	69.17	9	9	9	9
X_2 FRV_3	89.56	39.39	153.00	39	39	39	39
X_3 FRV_4	1092.54	795.56	1283.76	1990	795	1262	1406
X_4 FRV_5	1444.61	1083.10	1593.55	1083	775	1083	1083
X_5 FRV_7	50.72	5.22	120.00	(200)	(200)	(50)	(50)
X_6 FRV_{10}	70.01	39.47	145.00	39	39	39	39
X_7 FRV_{12}	36.05	15.49	55.69	38	15	115	77
X_8 FRV_{14}	.96	.01	10.00	0	16	0	0
X_9 FRV_{19}	19781.75	16677.56	24000.00	23,388	16,978	18,735	20,176
X_{10} FRV_{20}	31.17	15.94	100.00	16	16	16	16
X_{11} FRV_{21}	56.03	15.91	76.40	60	15	85	85
X_{12} FRV_{22}	3.17	.01	10.68	0	0	0	0
X_{13} FRV_{24}	9.88	2.05	17.07	40	75	42	38
X_{14} FRV_{25}	1120.82	860.65	1306.08	(867)	(867)	(867)	(867)
X_{15} FRV_{26}	530.88	409.65	800.00	(409)	(409)	(409)	(409)
X_{16} FRV_{27}	1.32	.01	20.00	0	0	0	0
X_{17} FRV_{28}	66.73	32.70	140.00	208	479	117	81
X_{18} FRV_{29}	1.20	.01	3.01	13	0	7	7
X_{19} FRV_{31}	5.35	.81	12.17	66	80	79	79
X_{20} FRV_{32}	17.16	3.86	50.00	3	56	3	3
X_{21} FRV_{33}	8.63	3.22	16.51	3	3	3	3
X_{22} FRV_{36}	83.89	42.00	140.27	211	533	121	86
X_{23} FRV_{67}	3.93	.63	25.00	0	0	11	11
X_{24} FRV_{68}	69.77	40.80	120.00	40	40	132	76
X_{25} FRV_{69}	2.56	.91	8.00	6	0	0	0
X_{26} FRV_{51}	56.33	31.72	300.00	31	31	31	31
X_{27} FRV_{52}	21.23	9.30	34.15	9	9	9	9
X_{28} $TSCP_1$	15.08	5.76	31.02	10.6	0.0	11.6	10.5
X_{29} $TSCP_2$	.50	0	1.0	0.0	0.0	0	.9
X_{30} $TSCP_7$	27.93	20.44	65.92	25.5	41.2	65.9	65.9
X_{31} $TSCP_8$	43.45	31.70	56.15	NA	NA	NA	NA
X_{32} COM_2	18683.76	14669.40	22758.90	0.0	0.0	NA	NA
X_{33} COM_3	76716.81	44893.80	126186.00	44,894.0	44,894.0	0.0	0.0
X_{34} $APNX_1$	.6	0	1.0	(0.0)	(0.0)	0.0	0.0
X_{35} $APNX_2$	.5	0	1.0	(0.0)	(0.0)	0.5	0.5
X_{36} $APNX_3$	.5	0	1.0	(0.0)	(0.0)	0.5	0.5
X_{37} $APNX_4$	.5	0	1.0	(0.0)	(0.0)	0.5	0.5
X_{38} $APNX_7$	.6	0	1.0	(0.0)	(0.0)	0.6	0.6
X_{39} $APNX_8$	.6	0	1.0	(0.0)	(0.0)	0.0	0.0
X_{40} $APNX_9$	.4	0	1.0	(0.0)	(0.0)	0.0	0.0

[1] 53 School Districts included (Fishers Island excluded). Upper bound is the mean of the upper 20% of S.D. Similarly, the lower bound is the mean of 20% of S.D.

*Indicates objective not met

‡Budgetary slack = 0

#Indicates dropout (O_{18}) rate exceed the desired target of .08

Note: Budget of $3506 per pupil implys:

$$\sum_{k=1}^{27} C_k X_k \le 3506 \; ; \; k \ne 9,22$$

Where;

C_k = .55, k = 3 (proportion of students K-6)
.45, k = 4 (proportion of students 7-12)
.1, k = 5 (proportion of students under PSEN)
1.0, otherwise

Table IV (Continued)

1 Outcome Variable Code	2 Mean Value	3 Lower Bound Value	4 Upper Bound Value	5 Desired Ed. Target	10 Scenario 3 Solution $3506/Pupil‡	11 Scenario 3 Solution $3150/Pupil‡
O_1	919	.8400	.9900	.969	.96	.96
O_2	931	.7200	9900	.931	.93	.93
O_3	711	.2500	.9500	.811	.84	.83
O_4	806	4100	.9900	.936	.95	.95
O_5	674	.3333	.9324	.774	.77	.77
O_6	628	3844	.9267	.678	.90	.82
O_7	520	2653	9993	.54	.99	.93
O_8	749	1579	.9590	.949	.98	.96
O_9	.506	.2500	8263	.786	.78	.78
O_{10}	762	.3846	9167	.962	.86	.86
O_{11}	.763	0588	.9603	.86	.86	.86
O_{12}	810	4091	9990	.56	.85	.85
O_{13}	775	1176	9990	.925	.99	.95
O_{14}	805	.2747	.9990	.925	.82	.82
O_{15}	367	1786	8511	.567	.56	.56
O_{16}	280	.1043	4286	.38	.37	.37
O_{17}	.313	.0266	5190	.313	.31	.31
O_{18}	180	0068	4786	.08	.021	.0316

Input Variable Code/Name	Mean Value	Lower Bound Value	Upper Bound Value		
X_1 FRV_2	54.61	9.32	69.17	9	9
X_2 FRV_3	89.56	39.35	153.00	39	39
X_3 FRV_4	1092.54	795.54	1283.74	847	930
X_4 FRV_5	1444.61	1083.10	1593.55	1,083	1,083
X_5 FRV_7	50.72	5.22	120.00	(5)	(5)
X_6 FRV_{10}	70.01	39.47	145.00	39	39
X_7 FRV_{12}	36.05	15.49	55.69	128	54
X_8 FRV_{14}	94	.01	10.00	0	0
X_9 FRV_{19}	19781.75	16677.56	24000.00	15,259	15,987
X_{10} FRV_{20}	31.17	15.94	100.00	16	16
X_{11} FRV_{21}	56.03	15.91	76.40	82	49
X_{12} FRV_{22}	3.17	.01	10.68	0	0
X_{13} FRV_{24}	9.88	2.05	17.07	66	36
X_{14} FRV_{25}	1120.82	860.45	1306.08	(867)	(867)
X_{15} FRV_{26}	530.88	409.45	800.00	(409)	(409)
X_{16} FRV_{27}	1.32	.01	20.00	0	0
X_{17} FRV_{28}	66.73	32.70	140.00	129	111
X_{18} FRV_{29}	1.20	.01	3.01	0	0
X_{19} FRV_{31}	5.35	.81	12.17	66	25
X_{20} FRV_{32}	17.16	3.86	50.00	3	3
X_{21} FRV_{33}	8.63	3.22	16.51	3	3
X_{22} FRV_{36}	83.89	42.00	140.27	133	114
X_{23} FRV_{47}	3.93	.63	25.00	11	0
X_{24} FRV_{48}	69.77	40.80	120.00	152	92
X_{25} FRV_{49}	2.56	.91	8.00	0	0
X_{26} FRV_{51}	56.33	31.72	500.00	31	31
X_{27} FRV_{52}	21.23	9.30	34.15	9	9
X_{28} $TSCP_1$	15.08	5.76	31.02	10.4	10.0
X_{29} $TSCP_2$	.50	0	1.0	0.0	0.0
X_{30} $TSCP_7$	27.93	20.44	45.92	45.9	29.1
X_{31} $TSCP_8$	43.45	31.70	56.15	NA	NA
X_{32} COM_2	18683.76	14669.40	22738.90	0.0	0.0
X_{33} COM_3	76716.81	44893.80	126186.00	0.0	67,187.1
X_{34} $APNX_1$	.6	0	1.0	0.0	0.0
X_{35} $APNX_2$	.5	0	1.0	1.0	1.0
X_{36} $APNX_3$	.5	0	1.0	1.0	1.0
X_{37} $APNX_4$	.5	0	1.0	1.0	1.0
X_{38} $APNX_7$	.6	0	1.0	1.0	1.0
X_{39} $APNX_8$	.6	0	1.0	0.0	0.0
X_{40} $APNX_9$	.6	0	1.0	0.0	0.0

[1] 53 School Districts included (Fishers Island excluded). Upper bound is the mean of the upper 20% of S.D. Similarly, the lower bound is the mean of 20% of S.D.

*Indicates objective not met

‡Budgetary slack = 0

#Indicates dropout (O_{18}) rate exceed the desired target of .08

Note: Budget of $3506 per pupil implys:

$$\sum_{k=1}^{27} C_k X_k \le 3506 \; ; \; k \ne 9,22$$

Where;

C_k = .55, k = 3 (proportion of students K-6)
.65, k = 4 (proportion of students 7-12)
.1, k = 5 (proportion of students under PSEN)
1.0, otherwise

The solutions for Case II (see Table IV above), can be used in the decision making process regarding the educational finance policies of a school district in transition. For instance, should the school district deteriorate into a poorly performing district (denoted by a value of "0" for variables X_{34} - X_{40}), the desired educational targets (see Table IV, col. 5,7) will not be realized with a budget of $3150 per pupil. These targets however can be realized with a budget of $3506 per pupil, providing the community wealth index (X_{33}) is at least $44,894. Since the budget slack in this instance is equal to zero, it is unwarranted to reduce it below $3506/pupil. The distribution of that budget over the various functions has some policy implications. In Scenario 1 (poor district) for instance, the simulation procedure calls for the allocation of resources (financial) which are much larger than the county average for educational functions; X_3 (instructional salaries K-6), X_9 (av. teacher salary), X_{17} (BOCES - teaching), and X_{18} (BOCES - pupil and community service) and X_{19} (contractual adm./planning). In other words, to realize the preemptive targets or objectives (col. 3, Table IV) of Scenario 1 (poor district), it will be necessary to allocate much more resources for these educational functions. The increased spending on functions X_3 and X_9 for example, imply that the pupil/teacher ratio should be reduced for elementary schools, and "better" teachers (i.e., higher paid) should be hired.† Also, increased expenditures on BOCES and contractual services will be required to realize the desired targets of this scenario.

Should the "pupil quality" indices (X_{34} - X_{40}) remain at the level indicated in Scenario 2 (see Table IV, col. 8), the aforementioned targets can be realized with a budget of \$3506/pupil and/or \$3150/pupil, regardless of the community index (X_{33}) value. The targets could be realized at the lower budget because of a "slack" of \$367 per pupil that was observed while simulating Scenario 2 (with a budget of \$3506/pupil). Notice that in this instance (Scenario 2) the allocation of funds for function X_3 and X_7 is larger than the county mean, whereas the money allocated for function X_4 is below the county mean. The implication of these findings is that the pupil/teacher ratio for high schools could be increased (hence the class size too) and this ratio should be decreased for elementary schools.

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†This simulation result seems to complement the finding of a recent RAND Corp. study and a policy position held by N.Y.S. School Board Assoc. [See Empire State Report Weekly April 30, 1984.]

The simulation results of Scenario 3 (Table IV, col. 10 and 11) denotes that a lower budget (\$ 3150/pupil) will be sufficient to ascertain the desired educational targets (of a "rich district"), providing the community (X_{33}) index (for that district) is \$67,187 and each of the pupil qualification indices (X_{35} - X_{38}) have an integer value of one (1). Notice that in this scenario the solution values of both X_3 and X_4 are below the county average. The same can be said for variable X_9 (average teacher salary). On the other hand, the expenditure on functions; X_7 (interscholastic athletics), X_{11} (school library), X_{17} (BOCES - teaching) and X_{19} (contractual, planning/development) should be increased to a level which is above the county average.

c. *Case III - Districts Within a Region (BOCES I)*

The simulation of alternative scenarios of a single district were discussed in the preceeding sections, whereas in this section the financial requirements for various types of districts (within a region) are discussed. BOCES I districts (located in eastern Long Island) were selected for this endeavor.

Hence, upon consultation with Dr. Raymond A. DeFeo, BOCES I[1] Region Superintendent, and Dr. Gerald LaMantia, it was decided to simulate the financial requirements of 3 types of districts; namely low, average and high performing districts. A single set of desired educational (outcomes) targets, priorities and weights were developed for the various scenarios, whereas the 3 types of districts (denoted by various scenarios) were defined in terms of their community, school and pupil attributes. Hence in this case, just as was done in Case II, certain pupil, school and community variables were bounded on one side only, while others were "pegged" at a given value. Variable X_{29} on the other hand, was "fixed" at "0" because none of the schools of that region have enrollment greater than 3000 pupils. The overhead variables (X_{14}, X_{15}) were also pegged. This information is summarized in Table V below, whereas the solutions for the scenarios of this case are recorded in Table VI that follows.

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[1] BOCES is an acronym for Board of Cooperative Education Services

Table V

Case III: East End School Districts (BOCES I)

-Educational outcome targets, priorities and weights.

Outcome O_i	Target For O_i	"Transformed" Target $G_i = Q_i - A_i$	Priority Class of i	Deviational Variable Minimized	Weight Within Priority Class
1	.919	-1.091 *	2	d^+	.25
2	.941	- .041 *	2	d^+	.1
3	.861	2.214	2	d^-	.3
4	.886	.201	2	d^-	.35
5	.884	-2.779 *	3	d^+	.45
6	.788	1.316	3	d^-	.4
7	.62	4.86	3	d^-	.15
8	.949	4.964	4	d^-	.5
9	.836	2.909	4	d^-	.5
10	.852	.65	5	d^-	.25
11	.86	1.025	5	d^-	.2
12	.85	- .495 *	5	d^+	.15
13	.845	.716	5	d^-	.15
14	.845	-2.554 *	5	d^+	.25
15	.507	.958	6	d^-	.5
16	.36	- .455	6	d^+	.25
17	.253	-1.983	6	d^+	.25
18	.04	-3.348	7	d^-	1.0

*These objectives (i.e., transformed objectives) multiplied by -1 as in Case I.

Lower bound for financial variables in this case are as follows;

Variable X_i	Lower Bound
X_i; i = 1-4, 6-27	Same as in Case I
X_5	fixed at 50.72

(NOTE: **Maintaining bounds are priority 1 objectives**)

- Pupil, school and community attributes variables have the following upper bounds conforming for 3 scenarios;

	Upper Bound		
Variable, X_i	Scenario 1	Scenario 2	Scenario 3
X_{28}	31.02	31.02	31.02
X_{29}	0 (fixed)	0 (fixed)	0 (fixed)
X_{30}	45.92	45.92	45.92
X_{31}	56.15	56.15	56.15
X_{32}-X_{40}	**Lower bound** +	**Mean**	**Upper bound**

+NOTE: In scenario 1 variables X_{34} - X_{40} were fixed (pegged) at "0".

To simulate the resource requirements for Case III - Scenario 1 (low performing district), the school size (X_{29}) and pupil quality (X_{34} - X_{40}) indices were pegged at a value of zero, whereas variable X_5 was pegged at 50. The community wealth and income indices (X_{32}, X_{33}) were bounded on one side only. Hence, the upper bound of variable X_{33} was set at $44,893 for this scenario. Finally, two budget configurations were used while simulating Scenario 1 of Case III.

The solutions for Case III, as denoted below in Table VI, provide some useful information for the decision making process regarding the educational finance policies of the east end districts. The desired educational targets (see column 5, Table V) according to the simulation results, can be realized under conditions set by the various scenarios and budget configurations. The distribution of the alternative budget configurations over the various educational functions, also contain some policy implications. For instance, the value of X_3 is above the county average for the two budget configurations (see col. 6, 7, Table V), whereas the value of X_4 is below that average. The implication thereof is that the pupil/teacher ratio should be decreased for elementary schools, whereas that ratio should be increased for high schools of a poorly performing district. Moreover, the simulation results call for a larger amount of money to be allocated (by that district) for education functions such as: X_{17} (BOCES - teaching) and X_{19} (contractual-adm./planning/improvement). Finally, the results indicate that a poorly performing district could realize the desired educational targets with the lower budget (i.e., $3150/pupil), providing the community

Table VI

Case III Simulation Results
East End (BOCES I Dist.)

1 Outcome Variable Code	2 Mean Value	3 Lower Bound Value	4 Upper Bound Value	5 Desired Ed. Target	6 Scenario 1 Solution $3506/Pupil‡	7 Scenario 1 Solution $3150/Pupil‡‡	8 Scenario 2 Solution $3506/Pupil‡‡‡	9 Scenario 2 Solution $3000/Pupil‡‡
O_1	.919	8400	.9900	.919	.91	.91	.91	.91
O_2	.931	7200	9900	.941	.94	.94	.94	.94
O_3	711	2500	.9500	.861	.66	.86	.86	.86
O_4	806	4100	.9900	.886	.88	.93	.89	.88
O_5	.674	3333	.9324	.884	.88	.88	.88	.88
O_6	[illegible]	3844	.9267	.788	.86	.88	.84	.87
O_7	520	2853	.9993	.62	.99	.98	.99	.93
O_8	745	1579	.9990	.949	.97	.94	.96	.94
O_9	585	2500	8265	.836	.83	.83	.83	.83
O_{10}	.762	3846	.9167	.852	.85	.85	.85	.85
O_{11}	763	0585	.9602	.86	.85	.85	.85	.93
O_{12}	810	4091	.9990	.85	.85	.85	.85	.85
O_{13}	775	1176	9990	.845	.98	.92	.98	.90
O_{14}	605	2747	9990	.845	.84	.89	.84	.91
O_{15}	.367	1786	8511	.507	.50	.50	.50	.50
O_{16}	280	1043	4286	.16	.36	.36	.36	.31*
O_{17}	313	0266	.5190	.253	.25	.25	.25	.25
O_{18}	180	0068	4786	.04	.02	.02	.02	.02

Input Variable Code/Name	Mean Value	Lower Bound Value	Upper Bound Value					
X_1 FRV_2	54.61	9.32	69.17		6	6	6	6
X_2 FRV_3	89.56	39.35	153.00		39	39	39	39
X_3 FRV_4	1092.54	795.54	1283.74		1243	1470	1087	1359
X_4 FRV_5	1444.61	1083.10	1593.55		1083	1083	1087	1083
X_5 FRV_7	50.72	5.22	120.00		(50)	(50)	(50)	(50)
X_6 FRV_{10}	70.01	39.47	145.00		39	39	39	39
X_7 FRV_{12}	36.05	15.49	55.69		96	32	122	15
X_8 FRV_{14}	.94	.01	10.00		9	4	9	3
X_9 FRV_{19}	19781.75	16677.56	24000.00		18743	20737	17366	19757
X_{10} FRV_{20}	31.17	15.94	100.00		[illegible]	16	16	14
X_{11} FRV_{21}	56.03	15.91	76.40		75	53	75	38
X_{12} FRV_{22}	3.17	.01	10.68		0	0	0	0
X_{13} FRV_{24}	9.88	2.05	17.07		35	36	33	36
X_{14} FRV_{25}	1120.62	860.45	1306.08		(867)	(867)	(867)	(867)
X_{15} FRV_{26}	530.88	409.45	800.00		(409)	(409)	(409)	(409)
X_{16} FRV_{27}	1.32	.01	20.00		0	0	0	0
X_{17} FRV_{28}	66.73	32.70	140.00		162	72	198	136
X_{18} FRV_{29}	1.20	.01	3.01		[illegible]	11	6	6
X_{19} FRV_{31}	5.35	.81	12.17		3	61	98	[illegible]
X_{20} FRV_{32}	17.16	3.86	50.00		3	3	3	3
X_{21} FRV_{33}	8.63	3.22	16.51		3	3	3	3
X_{22} FRV_{36}	83.89	42.00	140.27		166	76	201	140
X_{23} FRV_{47}	3.93	.63	25.00		0.48	0.00	0.08	0.00
X_{24} FRV_{48}	69.77	40.80	120.00		70	40	82	45
X_{25} FRV_{49}	2.56	.91	8.00		0	0	0	0
X_{26} FRV_{51}	56.33	31.72	500.00		31	31	31	31
X_{27} FRV_{52}	21.23	9.30	34.1[illegible]		9	9	9	9
X_{28} $TSCP_1$	15.08	5.76	31.02		14.5	13.2	12.2	22.3
X_{29} $TSCP_2$	50	0	[illegible].0		(0.0)	(0.0)	(0.0)	(0.0)
X_{30} $TSCP_7$	27.93	20.44	[illegible]5.92		45.9	31.1	45.9	26.8
X_{31} $TSCP_8$	43.45	31.70	56.15		NA	NA	NA	NA
X_{32} COM_2	18583.76	14669.40	22758.90		0.0	0.0	0.0	0.0
X_{33} COM_3	76716.81	44893.80	126186.00		0.0	44894.0	0.0	76717.0
X_{34} $APNX_1$	6	0	1.0		0.0	0.0	0.0	0.0
X_{35} $APNX_2$	5	0	1.0		0.0	0.0	0.5	0.5
X_{36} $APNX_3$	5	0	1.0		0.0	0.0	0.5	0.5
X_{37} $APNX_4$	5	0	1.0		0.0	0.0	0.5	0.5
X_{38} $APNX_7$	4	0	1.0		0.0	0.0	0.4	0.4
X_{39} $APNX_8$	4	0	1.0		0.0	0.0	0.0	0.0
X_{40} $APNX_9$	4	0	1.0		0.0	0.0	-0.0	0.0

[1] 33 School Districts included (Fishers Island excluded). Upper bound is the mean of the upper 20% of S.D. Similarly, the lower bound is the mean of 20% of S.D.

*indicates objective not met

‡budgetary slack = $337

‡‡budgetary slack = $0

‡‡‡budgetary slack = $367

( )figures in parenthese indicate fixed variable

#indicates dropout (O_{18}) rate exceed the desired target

Note: Budget of $3506 per pupil (or $3150) implys:

$$\sum_{k=1}^{27} C_k X_k \leq 3506 \ ; \ k \neq 9,22$$

Where:

C_k = .55, k = 3 (proportion of students K-6)
.45, k = 4 (proportion of students 7-12)
.1, k = 5 (proportion of students under PSEN)
1.0, otherwise

Table VI

(continued)
Case III Simulation Results
East End (BOCES I)

1 Outcome Variable Code	2 Mean Value	3 Lower Bound Value	4 Upper Bound Value	5 Desired Ed. Target	10 Scenario 3 Solution $3506/Pupil‡	11 Scenario 3 Solution $3000/Pupil‡‡
O_1	.919	.8400	.9900	.919	.91	.98
O_2	.931	.7200	.9900	.941	.94	.99
O_3	.711	.2500	.9500	.861	.86	.86
O_4	.806	.4100	.9900	.886	.97	.94
O_5	.674	.3333	.9324	.884	.88	[illegible]
O_6	.628	.3844	.9267	.788	.87	.84
O_7	.520	.2653	.9990	.62	.99	.91
O_8	.749	.1579	.9990	.949	.97	.94
O_9	.586	.2500	.8269	.836	.83	.83
O_{10}	.762	.3846	.9167	.852	.86	.86
O_{11}	.760	.0538	.9608	.86	.85	.85
O_{12}	.810	.4091	.9990	.85	.85	.85
O_{13}	.775	.1176	.9990	.845	.98	.93
O_{14}	.805	.2747	.9990	.845	.84	.84
O_{15}	.367	.1786	.8511	.507	.50	.50
O_{16}	.280	.1043	.4286	.36	.50	.36
O_{17}	.313	.0266	.5190	.253	.25	.25
O_{18}	.180	.0068	.4786	.04	.02	.03

Input Variable Code/Name	Mean Value	Lower Bound Value	Upper Bound Value		
X_1 FRV_2	54.61	9.32	69.17	6	9
X_2 FRV_3	89.56	39.35	153.00	39	39
X_3 FRV_4	1092.54	795.54	1283.74	1320	1088
X_4 FRV_5	1444.61	1083.10	1593.55	1083	1083
X_5 FRV_7	50.72	[illegible]	120.00	(50)	(50)
X_6 FRV_{10}	70.01	39.47	145.00	39	39
X_7 FRV_{12}	36.05	15.49	55.69	86	87
X_8 FRV_{14}	.94	.01	10.00	0	6
X_9 FRV_{19}	19781.75	16677.56	24000.00	19421	17379
X_{10} FRV_{20}	31.17	15.94	100.00	16	16
X_{11} FRV_{21}	56.03	15.91	76.40	75	15
X_{12} FRV_{22}	3.17	.01	10.68	0	0
X_{13} FRV_{24}	9.88	2.05	17.07	37	33
X_{14} FRV_{25}	1120.82	860.45	1306.08	(867)	(867)
X_{15} FRV_{26}	530.88	409.45	800.00	(409)	(409)
X_{16} FRV_{27}	1.32	.01	20.00	0	0
X_{17} FRV_{28}	66.73	32.70	140.00	145	203
X_{18} FRV_{29}	1.20	.01	3.01	0	0
X_{19} FRV_{31}	5.35	.81	12.17	92	42
X_{20} FRV_{32}	17.16	3.86	50.00	3	3
X_{21} FRV_{33}	8.63	3.22	16.51	3	3
X_{22} FRV_{36}	83.89	42.00	140.27	149	207
X_{23} FRV_{47}	3.93	.13	25.00	0	0
X_{24} FRV_{48}	65.77	40.40	120.00	75	89
X_{25} FRV_{49}	2.56	.91	8.00	0	0
X_{26} FRV_{51}	56.33	31.72	500.00	31	31
X_{27} FRV_{52}	21.23	9.30	34.15	9	9
X_{28} $TSCP_1$	15.08	5.76	31.02	7.8	9.1
X_{29} $TSCP_2$	.50	0	1.0	0.0	0.0
X_{30} $TSCP_7$	27.93	20.44	45.92	45.9	28.2
X_{31} $TSCP_8$	43.45	31.70	56.15	NA	NA
X_{32} COM_2	18683.76	14669.40	22758.90	0.0	0.0
X_{33} COM_3	78716.81	44893.80	126184.00	0.0	53238.5
X_{34} $APMX_1$	.6	0	1.0	0.0	1.0
X_{35} $APMX_2$	.5	0	1.0	1.0	1.0
X_{36} $APMX_3$	.5	0	1.0	1.0	1.0
X_{37} $APMX_4$	.5	0	1.0	1.0	1.0
X_{38} $APMX_7$	.4	0	1.0	1.0	1.0
X_{39} $APMX_8$	.4	0	1.0	0.0	0.0
X_{40} $APMX_9$	.4	0	1.0	0.0	1.0

[1] 53 School Districts included (Fishers Island excluded). Upper bound is the mean of the upper 20% of S.D. Similarly, the lower bound is the mean of 20% of S.D.

‡budgetary slack = $347

‡‡budgetary slack = $0

( )figures in parentheses indicate fixed variable.

wealth index is at least $44,894. These targets however, are ascertained (by the technique) through the shifting of financial resource. Hence, under the lower budget configuration money is shifted away from supporting functions or services (i.e., X_7, X_{17}, X_{19}, X_{22} and X_{24}) into direct educational functions (i.e., X_3 and X_9). Notice that the similar shifting of funds can be found in Scenario 2 solutions.

In Scenario 3 (well performing districts), on the other hand, the money shifting phenomenon is reversed. In other words, money is shifted from direct educational functions (i.e., X_3 and X_9) into indirect educational functions (i.e., X_7, X_{17}, X_{22}, X_{24}) whenever the budget is reduced (from $3500/pupil to $3000/pupil). Recall that well performing districts in this case are denoted by the value of one (1) for most "pupil quality" indices (X_{34} - X_{40}). That is to say that a well performing district is "endowed" by pupils who "scored" in previous year tests, above the county average.

IV. IMPROVEMENT OF THE PROCEDURE

An assertion can be made that the effectiveness of a resource allocation procedure rest in the ability of the analyst(s) to capture relevant features of the system in question, quantitatively. Hence, although results provided in the preceeding pages are very promising, they could be improved through the utilization of;

- an improved pupil performance and resource utilization model
- alternative and related resource allocation procedures.

A. Modification of Pupil Performance and Resource Utilization Model

The pupil performance and resource utilization model is the foundation for the application of the technique, discussed thus far, inasmuch as it is portraying certain input-output relationships of the educational process. To enhance the results obtained from the application of this approach, that model could be modified. In its current form, the model has a logistic structure, and as such, it can be dubbed as a "prospective" model. An improved model could be developed through the construction of a "retrospective" logistic model (see Farewell, 1979). This improved model should also include "interactive" and logged explanatory variables. A discussion concerning such an improved model can be found elsewhere (see Spottheim, Libassi, 1984), and in the previous chapter of this report.

B. Application of Related Resource Allocation Procedures

The goal programming technique used in this endeavor is a computational procedure which belongs to the field of multiobjective decision analysis. This field contains other relevant techniques (i.e., "prior articulation of preferences" techniques) that can be used instead of our current method. For instance, one could test the applicability of a "Piecewise Linearization Technique" (see Loucks et. al., 1979) to the problem of resource allocation within school districts, and compare the results obtained via this method against those generated by the goal programming technique.

V. SUMMARY

In the preceding sections, the application of a "goal programming" technique to the problem of resource allocation within school districts, was discussed and the results of such an application were presented. In this section, a recapitulation of this effort is presented.

The objective of this endeavor was to demonstrate that a proven management science technique could be applied to the educational resource allocation problems. Results generated by the technique could then be used by the districts as criteria for allocating resources with respect to some prioritized educational targets.

In the course of this effort the pupil performance and financial resource utilization model was developed and used in conjunction with the goal programming technique to simulate various scenarios. While the results of this endeavor are very revealing and promising, the approach discussed thus far can be improved through:

- utilization of an improved pupil performance and financial resource utilization model
- application of related allocation procedures.

In sum, the application of the aforementioned approach should not be viewed as a mysterious process. Rather, it is an approach or a management tool which portrays the structure and behavior of certain education processes and consequently, could be used by educational decision makers to allocate resources needed for realizing prioritized educational goals. A similar approach could be used by the state to determine a "supplementary" state aid for low performing districts.

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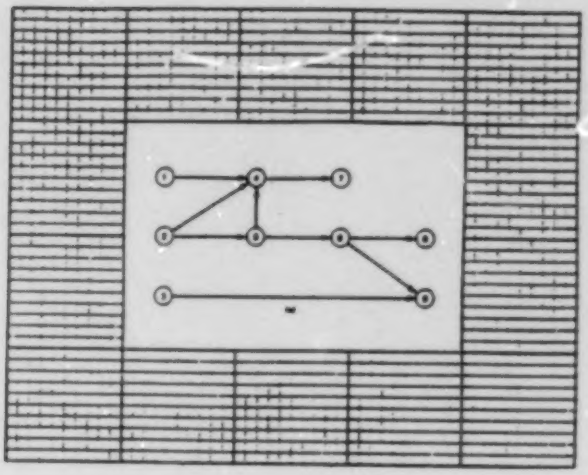

CHAPTER IV.

THE OPERATIONAL STRUCTURE OF A SCHOOL SYSTEM AND PUPIL PERFORMANCE: A PUPIL FLOW MODEL

THE OPERATIONAL STRUCTURE OF A SCHOOL SYSTEM AND PUPIL PERFORMANCE: A PUPIL FLOW MODEL ‡

I. INTRODUCTION

The rising cost of rendering educational services and the concurrent increase of tax burden to finance these services have intensified the debate concerning the relationships between pupil achievement and the educational processes used within a system. Lately, this debate has been transformed into a public demand for improved services through the adoption of "effective" teaching methods and efficient educational administrative policies (see Schorr in WSJ Dec. 15, 1983).* Concurrently, various commissions were established to investigate the educational problems and their recommendations were widely reported in the print media (WSJ Dec. 23, 1983; N.Y. Times Nov. 13, 1983). In essence, these recommendations call upon the public educational sector to implement policies such as:

- stiffer diploma requirements
- tougher academic standards
- improved teacher qualifications
- improved guidance and counseling services
- longer hours in school

While these recommendations are designed to improve the quality of education, they do not deal with the relationships between the educational processes used and the educational outcomes achieved. The lack of concern with the operational structure of the schools/educational processes used, and outcomes realized, also can be attributed to the prevailing education research paradigm (N.Y. Times, April 3, 1984). Rather than analyzing the educational processes and their outcomes, within the context the operational structure of the schools, these researchers tend to examine:

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‡This chapter is a revised copy of an earlier working paper (No. 13) by Spottheim/Wilson & a contribution by Lester Dubnick (May 1984).
*Authors cited henceforth are listed in alphabetical order in the bibliography at the end of this paper.

- schemes of pedagogical philosophy
- psychological, sociological and political processes observed in the systems
- narrow phenomena while using the case study and/or "ex post facto" methods of investigation.

Moreover, these studies lack adequate support by quantitative data, and as such, they are "anecdotal" in nature and cannot be replicated by other investigators in a different setting. While the approach used by educational researchers does not lend itself to policy-oriented inquiry, the management science approach can be used to examine the relationships between educational process and outcomes. Since this paper is an extension of the latter approach, it demonstrates how the application of "complex linear flow technique" can be used to portray these relationships in the context of the existing operations a structure of a school system.

A. The Problem

Granted the egalitarian educational philosophy in New York State, and the demand for effective administrative policies it can be argued that educators, administrators and legislators alike are currently in need of a methodology that can be used to analyze the policy predicament;

- What administrative adjustments could be implemented by a given educational jurisdiction, in order to attain some predetermined (and unified) educational goals for an array of pupils (with diversed attributes).

This predicament can be analyzed quantitatively, through the development of a model which portray the following properties of an educational services delivery organization:

- the educational components, administrative units, and other social elements involved in the educational process;
- the educational outcomes as portrayed by the interrelationships among such components and elements (units) and their relationship with the external socio-economic environment;
- the decisions and/or actions taken by the administrative components in their process of "matching" appropriate services with particular sets of pupils; and (adapted from Spottheim 1974, 1975).

B. The Approach

Although the contention held by educators is that the system is too complex for a quantitative inquiry, researchers in other fields have developed methodologies to address similar problems observed in other human service organizations (see Enscore 1972; Hasenfeld 1972; Spottheim 1974, 1975). Hence, a belated but useful process of amalgamating organizational theory (see Katz and Kahn 1966; Thompson, J.M. 1973), management sciences techniques (Rosenblatt 1960) along with complementary data, was used to portray the operational structure of an educational system and its outcomes.

This approach espouses the disaggregation of the system into a set of educational components and outcomes. Since several factors influence the educational outcomes (ends) the components (sectors) should portray both home environment and school attributes, namely:

- home and family environments
- pupil attributes

- teacher qualification/experience
- subjects taught
- pupil services available
- exam results (outcomes)

Primary pupil (flow) activities data must then be collected and the data tabulated in matrix form, thereby allowing for the construction of a model which denotes the administrative interrelationships existing among the "sectors" (elements) of the systems in question, and between these sectors and the outcomes. Hence, such a descriptive model portrays the educational system as a network of "semiautonomous" units which are linked together by a recurrent (routinized) flow of pupils, as was suggested in the literature (see Natale, Fall 1981). Unlike the previous model (Spottheim/Libassi 1984) the units of analysis of this model are pupils. Thus, detailed inferences can be drawn about the effect of certain educational resources upon the performance of specific types of pupils. It should be noted, however, that the suggested methodology does not deal with the "pedogogical processes" used (within a unit or classroom) while teaching the pupil specific skills and knowledge. It portrays the interrelationships between the existing elements (nodes) of the system only.

The purpose of this paper is to inform an interested audience about the approach used to develop this model and to present its final mathematical structure. The model was designed to be used in conjunction with operations research techniques to determine the "best" pupil flow patterns (within the system) that may lead to the realization of predetermined and/or desired outcomes. Thus, the remainder of this paper is structured as follows: Section II contains a brief review of the literature, whereas Section III contains a conceptual view of the system and theoretical model. In Section IV the proto type model is discussed, whereas the summary of this endeavor can be found in Section V.

II. REVIEW OF ALTERNATIVE APPROACHES

To analyze the issues of effectiveness and quality of education, researchers and educators alike have used various approaches. According to Cohn (1974) these approaches were developed by disciplines such as:

- educational philosophy
- educational psychology
- sociology/political science/organizational behavior
- educational policies
- economic and management science [adapted from Cohn 1974]

It should be noted, however, that the non-economic approaches are beset by problems which limit their applicability to handle the above issues. Such limitations are briefly presented below.

A. Limitation of the Non-economic Approaches

The educational philosophy studes are not easily replicated, inasmuch as they are based on the application of "ex post facto" method of investigation. Since they lack experimental procedures, they also tend to reflect the investigator's intrinsic feelings and taste [Ackoff/Emery, 1972]. While educational psychology studies are more rigorous than educational philosophy, they are "too micro" to have any administrative policy implication. The sociological/political science studies, on the other hand, tend to utilize the case study method. Since these studies are not supported by quantitative data, they seem to be "anecdotal" in nature. Finally, the educational policy studies which are an extension of title I (ESEA Program) are based on the suspicion that the skill level of pupils can be enhanced through the creation of categorical (or special) programs (e.g., "Headstart").

While aforementioned approaches are not amenable to policy decisions (due to lack of quantifiable data and concepts), economic/management science can be used to simulate the effect of alternative "recurrent pupil referrals" and financial policies upon the outcomes. The latter approach is based on the reconciliation of management science and/or economic concepts, with complementary quantitative methods and the appropriate data. The theories used in such studies include: educational production function, cost effectiveness, and the system approach. The advantage of these types of studies is that they provide a comprehensive view of the educational process in general and the issue effectiveness of educational services in particular [see Cohn 1974; Fox 1972].

Since a management science technique was used to develop the pupil flow model, a brief discussion concerning this approach is presented below.

B. The Economic Management Science Approach

The economic and management science approaches are based on the application of accepted theories along with proven techniques to policy problems. In the fields of health, education and welfare, they were used to address the problems of:

- the economic aspects of public finance
- organizational structure service provided and outcomes of human service delivery organizations.

Studies addressing the former problem tend to examine input/output relationships through the construction of models which then can be used to formulate (or modify) resource allocation policies (or practices) for a host of school districts. An example of this type of an approach can be found in educational studies by Chang (1980), Cohn (1974), Coleman (1966), Heim (1972), Wendling/Cohen (1981), and Spottheim/Libassi (1984).

Organizational structure and performance studies, on the other hand, are quantitative methods which examine the internal operational structure of an organization and its relationship to the "products" produced. In other words these studies examine the interrelationships among the various elements of an organization or system, composed of units such as: service stations, administration, support and related units. The approach taken in these studies is based on the application of a synthesized procedure which reconciles observed administrative data, management and administrative theories with complementary analytical techniques to portray the operation of the systems and its outcomes. Examples of such an approach concerning health and welfare institutions, can be found in studies conducted by Chatterji (1980), Cohen (1972), Coughlin (1964), Edward (1980), Griffin (1978), Harris (1977), Navarro (1969), and Spottheim (1974, 1975). On the other hand, Correa (1980) has used this approach to quantify the administrative interdependency among various governmental departments.

Although this management science approach produced a descriptive model, it can be applied to optimize the utilization of manpower, resources and facilities without changing the operational structure of the system in question, as was demonstrated by Cohen (1972), Enscore (1972), and suggested by Spottheim (1975).

III. A CONCEPTUAL VIEW OF THE SYSTEM AND THE THEORETICAL MODEL

The pupils flow model is an extension of the management sciences studies just reviewed, hence it is based on the application of system (organizational structure and performance) theories, along with the appropriate data and complementary techniques. According to this approach, an educational entity such as school district is perceived to be a "complex organization" (or an open system). The system is said to be composed of a network of "semi-autonomous" units (e.g., learning stations, administrative units, and households of different attributes) which are linked together through a recurrent flow of pupils. Since the system as a whole is a "purposeful" entity, the units thereof are involved in educational and administrative actions taken in relation to pupils. Thus, the presentation that follows commences with a discussion concerning the goals and outputs of the system, followed by an overview concerning the operational structure and processes of the system. This conceptual narrative is then presented formally, inasmuch as the embedded propositions thereof imply some mathematical form.

A. The Aim and Outputs of the Educational System

The purpose of the system (as a whole) is in essence the provision of educational services through a set of actions (educational and administrative) taken in relation to different types of pupils with the intention of assisting them to accumulate the certain level of knowledge and skill necessary to function as citizens in a contemporary society.

This aim is realized through the application of educational and administrative processes which transform the "status" of the pupils. These processes are manifested, among other things, in terms of pupil "referral" among educational and administrative units. The result of these referral patterns are a set of educational outcomes. Since these "referral" processes are said to be analogous to processes employed by other "human processing organizations," this model is based on a previous research effort (see Hasenfeld 1972; Spottheim 1974). Thus it was hypothesized that the multiple educational ends (i.e., outcomes or outputs) produced by these processes can be denoted (among other things) as possibilities concerning pupils who have:

- scored above or below state reference points (SRP) in selected 3rd and 6th grade proficiency exams administered by the State of New York
- scored above or below SRP in selected Regents competency tests (RCT) for grades 9-11
- passed or failed selected Regents graduation requirement tests
- graduated high school and left for a 4-year college
- graduated high school and left for a 2-year college and other institutions
- graduated high school and left for employment, military services and other destinations
- dropped out of school

While these educational outcomes measure the so-called "higher order reasoning," they do not measure what the pupils "actually learned." Since indices for measuring the latter concept are not ubiquitously available, it was decided to use the aforementioned probabilities as the outputs (or outcomes) of the system.

B. The Operational Structure and Processes of the System - A Conceptual Overview

The operational structure of the educational system is composed of various units (nodes) whereas the flow of pupils among the aforementioned units denotes the administrative interdependencies which exist among the components of the system. These interdependencies are due to the fact that these units share a common goal of assisting the pupil to gain the knowledge and skills necessary to function as a citizen in a contemporary society, and this goal can be measured in terms of the above-mentioned ends. To achieve these ends, the entities of the system in essence employs the process which transforms "inputs" into "outputs" (or outcomes).

The inputs[1] to the educational system (according to the suggested approach) are children with specified attributes, who enter the system because society perceives a need for providing them with education, to overcome undesired circumstances that may be faced by these children in the future. The intended outputs of the system are the pupils whose status skill and/or intellectual attributes have been changed in the direction of increased intellectual self reliance. The administration processes used to transform inputs into a set of intended outputs (outcomes) is referred generally in the literature as "organizational technology" (see Perrow 1972; March & Simon 1958).

Organizational technology has been defined as a complex of administrative actions employed upon, or in relation to, an object (e.g., pupil) in order to make some change in that object. (Perrow, 1972). Although different service delivery units within the same system may utilize different technologies (in the process of transforming the inputs into a set of outputs), such units share two common technological processes; namely, those of work-process and work-flow.

The former denotes the internal technological process used within an academic or "teaching" unit. It takes the form of an encounter between the pupil and the staff and personnel of a given unit (e.g., english, physics). The notion of work-flow, on the other hand, deals essentially with the "reciprocal" relationships among the units which share common (and predetermined) educational goals. These relationships are manifested in terms of the recurrent pupil and/or pupil-record flows among such units. The concepts of work-process and work-flow can be analogously related, respectively, to the administrative management concepts of "departmentalization" and "integration."

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[1] Notice the definition of input(s) in this model does not correspond to the one used in the earlier pupil performance model [Spottheim/Libassi 1984], whereas the output(s) in both models are analogously related.

Departmentalization is a managerial action which aggregates professionals who are engaged in similar work (or tasks) into a semiautonomous department or field (March and Simon, 1958). Such aggregation allows an academic department (i.e. english, chemistry) to carry out the teaching task (work-process) most efficiently. *Integration* implies that units which share a common goal and a reciprocal relationship in their work-flow processes can be arranged physically and/or administratively into an appropriate organization structure. In other words, departmentalization deals with work-process *within* an academic department, while integration concerns with the work-flow and/or the interdependencies *among* units. In essence, departmentalization makes an academic field of study relatively autonomous with respect to their teaching methods or work-process, thus allowing them to carry out their tasks efficaciously and contributing to the goals of the educational system. The analysis of work process however, is beyond the scope of this paper, whereas, workflow is a major concept of this analysis.

The contention can be made that the transformation of the input into output through "work-flow technology" in a given educational system is analgous to the process used by other service delivery systems. Such an analogy is apparent if one uses a framework which reconciles concepts such as technology, with an open systems theory and its quantitative counterpart.

Thus the model for the analysis of an educational system is analogous to an operational model that has been developed for the social services delivery systems (Spottheim, 1974, 1975). The underlying theoretical dimension of the latter model is a blend of concepts and methodology culled from sources such as administrative management theory, the system approach, and the complex linear flow technique. The model focuses on the "inter-sectorial" process (work-flow) of a health and welfare service delivery system. It identified the health service delivery units (sectors) that are involved in the provision of services but which are relatively autonomous in their internal operations though interdependent in their work-flow pattern. It also identified the types of services provided by the units of the system, the source of payment for service rendered. The model utilized patient referral patterns as a "common flow unit" to denote the flow among the units of the health service delivery system. Finally the model provided a host of impacts, effectiveness and simulations indices that were used as an administrative tool

Since the pupils flow patterns (in a school system) are analogous to the "clients" flow among the elements of the health and welfare system, both flows portray the operational structure of their respective systems as a whole, as well as their intended outcomes. Thus, by recording (over a fixed time period) these referral patterns into the system and through its elements, followed by the application of "Linear Flow" techniques to process such information, quantitative "snapshots" portraying the operational structure and outcomes of the school system could be provided. Such procedures could then be used to provide quantitative snapshots concerning:

- the probability that a pupil (with certain attributes entering the system through a particular unit will achieve a particular outcome (i.e., pass a given state administered exam)
- the average number of stations a pupil must go through before achieving a predetermined goal successfully
- the demand for services from particular units by different types of pupils

- the effect of national and/or state policies and requirements on selected administrative or educational units
- the simulation of an "idealized" organization structure and juxtaposition of units under different goals
- simulation of alternative flow pattern for a particular group of pupils (associated with a given program) for the purpose of realizing predetermined education goals

C. The Mathematical Form of the Theoretical Model

The preceding narrative concerning the operational structure, processes and outcomes of the educational jurisdiction can be expressed (symbolically) in a mathematical form. The advantage of this expression is that it lends itself to summarize the conceptual overview of the system, quantitative methods along with relevant theories and an array of administrative data into a manageable system of equations. Such an expression is in essence the theoretical model, to be calibrated and tested empirically. As was noted elsewhere, such an expression has other advantages inasmuch as it:

- explicitly illuminates the assumptions and definitions mentioned in the narrative
- rigorously defines relationships
- avoids the digression of vague arguments
- illuminates the limitation of the conceptual [Brennan, 1965].

The central theme behind the suggested model is that the just-discussed complex structure of a school system can be represented, mathematically, through the application of a "linear flow technique". This stochastic method is analgously related to the well known techniques of Markov chain and Leontief's Input/Output (Chiang, 1967). The application of this technique is based on the assumption that the operational structure of the system is reasonable "stationary" and the flow of pupils among the elements of that system is a recurrent overture. Since the technique provides a sufficiently accurate and quantitative description of the behavior of the system in question, it can serve as a tool in the management decision processes.

Recall that an educational system was perceived to be a "complex organization" composed of a discrete number of semi-autonomous units, which are linked together through a recurrent flow of pupils. Since the educational aim is a "collective goal" shared by the school and the community, these "semi-autonomous" units (nodes) are said to represent learning and administrative components of the educational system and household of different attributes. Thus, the mathematical counterpart of this system is composed of a matrix containing "m" sectors (or components). Each of the aforementioned semi-autonomous units is represented by a particular sector of this matrix.

The homogenous units flowing into, through and out of the system are said to be pupils. Input (of pupils) arriving from the "rest of the world" (ROW) can be received (theoretically) by selected sectors. These input units flow from one sector to another and the "leave" the system through prespecified (or closure) sectors. These closure sectors denote the outcome of the referral (or flow) processes. The flow patterns can be denoted by discrete mathematical values dubbed "technical coefficients", denoted noted by the symbol "$a_{i,j}$" which represent the proportion of the total input (external and internal) transferred by the j^{th} sector into the i^{th} sector of the system. The mathematical representation of the system can be written in matrix notation as follows:

1) $(I - A)X = Y$

or

2) $(I - A)^{-1}Y = X$

subject to

$$0 \leq a_{ij} \leq 1 \quad , \quad i,j = 1, \ldots, m$$

and

$$\sum_{i=1}^{m} a_{ij} \leq 1 \quad , \quad j = 1, \ldots, m$$

where:

$(I - A)^{-1}$ = inversed Leontief matrix

A = matrix of technical coefficients,

I = $m \times m$ identity matrix,

Y = external input vector of m elements,[2]

X = total activity vector of m elements.

The matrix notation implies that a complex linear flow model is a system of m linear equations in m unknowns, and each equation can be written as:

$$3)\ y_i = x_i - a_{i,1}x_1 - \ldots - a_{ij}x_j - \ldots - a_{im}x_m$$
$$= a_{i,1}x_1 - a_{i,2}x_2 - \ldots + (1 - a_{ii})x_i + \ldots - a_{im}x_m.$$

The technical coefficients matrix has to be computed from actual pupil flow data obtained by a sampling technique. Such flows are then transformed into a "transaction matrix" which gives the actual amount of the homogenous units moving between pair sectors. Hence, the technical coefficients matrix can be derived from the "transaction matrix" by using this simple equation.

$$4)\ a_{ij} = \frac{T_{ij}}{x_j} \qquad (j = 1,2, \ldots m;\ i = 1, 2, \ldots m)$$

---

[2] Notice the "Y" in this instance is a "vector" denoting the input to the system, whereas in the Leontief model such a vector denotes the "final demands" of the economic system.

$$\text{Hence,} \sum_{i-1}^{m} a_{ij} \leq 1$$

where

T_{ij} = the total demand by the jth sector on the i^{th} sector and x_j equals j's total activity.

The inverse of the Leontief matrix, $(I - A)^{-1}$ is reffered to as the "interdependency coefficients matrix"; it reveals considerable information about the system. An element of the interdependency coefficients matrix is symbolized as α_{ij}. Thus for each unit input that goes into the j^{th} sector, a "multiplier" effect can be found in the i^{th} sector. This response (effect) occurs due to a direct demand on the i^{th} sector by the j^{th} sector, or by an indirect demand. The response indices can be derived from the matrix, of the model, namely:

$a_{ij}y_j$ = total direct demand, on sector "i"

$\alpha_{ij}y$ = total direct and indirect demand, on sector "i"

$(\alpha_{ij} - a_{ij})y_j$ = total indirect demand, on sector "i"

Information provided by the interdependency coefficient matrix also can be used to estimate the average number of transfers an input (into a sector) goes through before it leaves the system. The number of transfers can be derived as follows:

$$m_j = \sum_{i=1}^{m} \alpha_{ij} \quad , \quad j = 1, 2, \ldots, m.$$

IV. A PROTOTYPE LINEAR FLOW MODEL FOR THE HUNTINGTON SCHOOL SYSTEM[1]

To test the applicability of the approach just discussed, a stratified sample of 246 pupils enrolled in grades 3,6 and 9 was assembled. A string of information concerning recurrent activities (flows) and educational outcomes for each of the sampled pupil was then collected and tabulated into a matrix form. Consequently, a "transaction matrix" containing 113 sectors ("default" sector included) was constructed and the "technical coefficients" were computed from this matrix. An empirical model which mimics the structure of the theoretical model (see equations No. 1 & 2) was then constructed through the application of the complex linear flow technique. This model is in essence, a quantitative "snapshot" portraying the operational structure and outcomes of the system in question. It provides considerable descriptive information about that system. "The sectors" of the model are listed in Table I, whereas the structure thereof is denoted in charts I.

A. The components of the Model

The model consist of three (square) matrices (whose sizes are 113 x 113) and 2 vectors.

These components are:

- Transaction matrix "T"
- Technical coefficient matrix "A"
- Inversed Leontief matrix, $[I-A]^{-1}$
- Input Vector
- Total Activity Vector

---

[1] Due to its size (113 x 113) the model is not included in this paper - a printout containing the various segments the model is available.

THE ADMINISTRATIVE STRUCTURE AND
PUPIL PERFORMANCE OF A SCHOOL SYSTEM
HUNTINGTON UNION FREE SCHOOL DISTRICT

TABLE I

LIST OF THE SYSTEM'S ELEMENTS
(Grades-3,6,&9 Only)

Sector No.	Data Code	
		I. HOME FAMILY ENVIRONMENTS
		Student's Birthplace:
1	HF$_1$	USA
2		Default - birthplace
3	HF$_3$	Asia
4	HF$_4$	Other
		Ethnic:
5	HF$_5$	Caucasian
6	HF$_6$	Black
7	HF$_7$	Hispanic - Caucasian
8	HF$_8$	Hispanic - Black
9	HF$_9$	Default - ethnic
10	HF$_{10}$	Oriental
11	HF$_{11}$	Other
		Father's Education:
12	HF$_{12}$	Elementary School
13	HF$_{13}$	High School
14	HF$_{14}$	College
15	HF$_{15}$	Graduate School
		Father's Occupation:
16	HF$_{16}$	Professional
17	HF$_{17}$	Managerial
18	HF$_{18}$	Blue Collar
19	HF$_{19}$	White Collar
		Previous Test Results and Defaults:
20	PT$_{20}$	3rd Grade Reading/Math Pass
21	PT$_{21}$	3rd Grade Reading/Math Fail
22		Default - father's education
23		Default - father's occupation
24		Default - Previous Test
25	PT$_{25}$	Failed in Math
26	PT$_{26}$	Pupil not Tested & Other
		Language Spoken at Home:
27	HF$_{27}$	Spanish
28	HF$_{28}$	French
29	HF$_{29}$	Other
		Income:
30	HF$_{30}$	Low Income
31	HF$_{31}$	Medium Income
		Siblings:
32	HF$_{33}$	Brother/Sisters - 3 or less
33	HF$_{34}$	Brothers/Sisters - More than 3
		Family:
34	HF$_{35}$	Intact
35		Default - Siblings
36		Default - Family
37	HF$_{38}$	Other than Intact
		II. TEACHER QUALIFICATIONS
38	T$_{53}$	BA
39	T$_{54}$	BA + 30
40	T$_{55}$	MA
41	T$_{56}$	MA + 15
42	T$_{57}$	MA + 30
43	T$_{58}$	MA + 45
44	T$_{59}$	MA + 60
45	T$_{60}$	Ph.D.
		Experience:
46	T$_{61}$	Less than 5
47	T$_{62}$	6 - 10
48	T$_{63}$	11 - 15
49	T$_{64}$	16 - 19
50	T$_{65}$	20+
		License - Elementary School:
51	T$_{66}$	Special Ed.
52	T$_{67}$	Common Branch
53		Default - Elem. License
54	T$_{70}$	Reading
55	T$_{71}$	ESL
56	T$_{72}$	Art and Music
57		Default - Secondary Teacher License

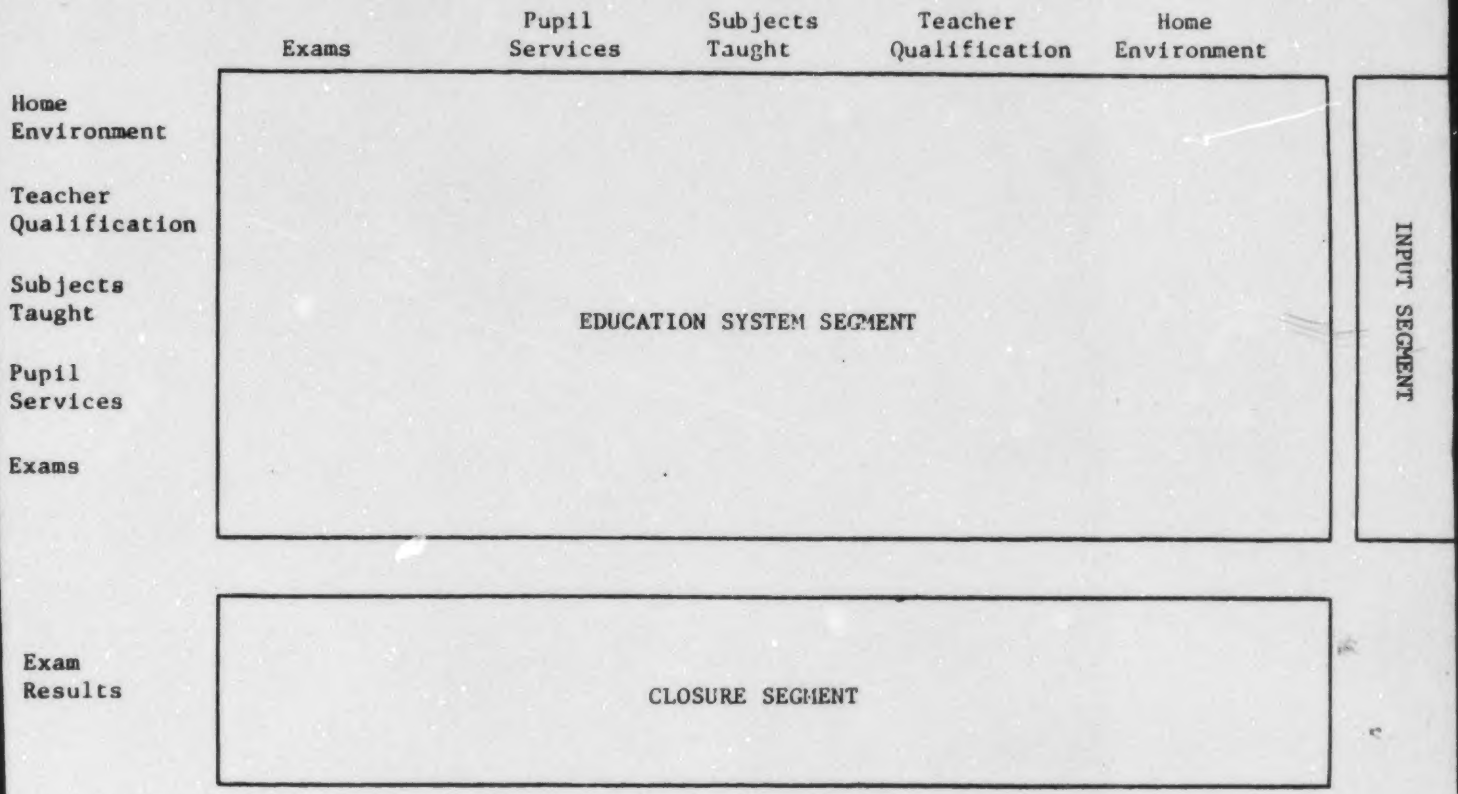
TABLE I (Con't.)

Sector No.	Data Code	
		Secondary Teaching License:
58	T_{74}	Social Studies
59	T_{75}	Math
60	T_{76}	Science
61	T_{77}	English
62	T_{78}	Combination
		III. SUBJECTS TAKEN BY PUPIL
		A. Grade K-6
63	E_{79}	Common Branch
64	E_{84}	Gifted
		B. Language Arts (English)
65	L_{87}	English 9
66	L_{90}	Communications 9
67	L_{97}	English 11 Y
68	L_{102}	Reading
		C. Foreign Language
69	F_{116}	Chinese I
70	F_{120}	ESL
71	F_{123}	French
72	F_{124}	French I
73	F_{125}	French II
74	F_{130}	German I
75	F_{133}	Italian I
76	F_{136}	Latin I
77	F_{140}	Spanish
78	F_{144}	Spanish III
		D. Math
79	M_{152}	Math Skills
80	M_{154}	General Math
81	M_{155}	Sequential Math I
82	M_{156}	SSMCIS 9
83	M_{157}	Seq. Math I
		E. Science
84	S_{174}	ISCS
85	S_{175}	Earth Science
86	S_{176}	Small Engines
87	S_{177}	T.V. Production
88	S_{178}	Photography
		F. Social Studies
89	SS_{197}	Social Studies 9

Sector No.	Data Code	
		G. Art
90	A_{219}	Creative Crafts
91	A_{220}	Basic Art
92	A_{225}	Ceramic Sculpture
		H. Industrial Art & Home Art
93	I_{232}	Woodworking
94	I_{233}	Metal Work
95	I_{244}	Power Mechanics
96	I_{247}	Foods
		I. Business Education
97	B_{254}	General Business
98	B_{255}	Typing - Full
99	B_{256}	Typing - 2 times
		J. Pupil Services
100	PS_{284}	Wilson Tech
101	PS_{290}	Resource/Aide
		IV. OUTPUTS
		A. Exams (Elementary School)
102	Q_{291}	Reading Exam 3rd Grade
103	Q_{294}	Reading Exam 6th Grade
104	Q_{296}	Stanford Achievement Test - Reading (9th Grade)
		V. RESULTS OF TESTS(CLOSURES)
105	X_{330}	3rd Grade Exams Pass (Reading or Math) i.e., above SRP
106	X_{331}	3rd Grade Exams Fail (Reading or Math) i.e., below SRP
107	X_{334}	6th Grade Exam (Reading or Math) Pass i.e., above SRP
108	X_{335}	6th Grade Exam (Reading or Math) Failed i.e., below SRP
109	X_{341}	Stanford Achievement Exam (9th Grade) Pass
110	X_{342}	Stanford Achievement Exam (9th Grade) Fail
111	X_{354}	Unknown Results/Default - Test Results
112	X_{355}	Dropout/Default - Output sec.
113	X_{357}	Error

Chart 1

Structure of Pupil Flow Model


Exams
Pupil Services
Subjects Taught
Teacher Qualification
Home Environment
Home Environment
Teacher Qualification
Subjects Taught
Pupil Services
Exams
EDUCATION SYSTEM SEGMENT
INPUT SEGMENT
Exam Results
CLOSURE SEGMENT

The Transaction Matrix "T" is a square matrix (113 x 113) denoting the flow of pupils between a pair of sectors. The numerical indices of this matrix depict the actual number of pupil flow from sector "j" (column) to another sector "i" (row). This matrix is also used to compute the technical coefficient matrix "A" discussed below.

The Technical Coefficient matrix "A" is also a square matrix (113 x 113) denoting the proportion (probability) of the total pupil input that were "transferred" by a given sector "j" directly to a sector "i". In other words, the elements "a_{ij}'s" of this matrix denote the proportional flow of pupils among the 113 sectors of the educational system. The coefficient a_{ij} for each sector was derived according to equation no. 4.

The Inversed Leontief Matrix is denoted by the symbol $(I-A)^{-1}$ and is derived from the above matrix. It describes the "interdependency" among the sectors of the system as portrayed by the flow of pupils. This matrix like the previous matrices is also a square matrix (113 x 113). It is referred to in the literature as an Interdependency coefficent matrix. The coefficient of this matrix is denoted by the symbol α_{ij} - they depict the proportion of the total pupil input that flows directly and indirectly from sector "j" to sector "i".

The Input Vector "Y" is composed of sectors 1-4 (see Table I). It denotes the various types of pupils (by birthplace) who arrive from the rest of the world (ROW) to begin their educational process. The total activity vector "X" contains information for each sector concerning the direct and intermediate (internally generated by the sectors of the system) inputs. Finally, sectors 105-113 in this model are said to be closures.

B. Expository Information Generated by the Model

The model as was noted earlier, portrays quantitative snapshots concerning operational structure, processes and outcomes of the system in question. Hence, some descriptive information concerning the system can be extracted from this model, specifically;

- the total effect
- the direct effect
- the indirect effect
- the multiplier

The total effect (or demand) as denoted by the symbol $(\alpha_{ij} \ Y_j)$ is a product of an interdependency coefficient (taken from the $[I-A]^{-1}$ matrix) and an input of pupils to a particular sector of the system. This effect provides information about the number of pupils arriving and indirectly from Sector j to Sector i. The direct effect (or demand) on the other hand, denoted by the symbol $(a_{ij} \ Y_j)$, provides information about the number of pupils arriving directly from the j^{th} Sector to the i^{th} Sector. This symbol is a product of a technical coefficient (taken from the "A" matrix) and an input of case/record to a particular j^{th} Sector. The indirect effect (or demand), as was noted earlier, provides information about the number of pupils arriving indirectly from the j^{th} Sector to the i^{th} Sector. This effect is denoted by the symbol $(\alpha_{ij} - a_{ij}) \ Y_i$ and is derived from the total and direct effects.

The interpretation of these effects is straightforward. For instance, the effects of Sector 1 on Sector 21 = $\alpha_{21,1}$ (230) = (.059) 230 = 13.9, that is to say that out of the U.S. born pupils entering the system, close to 14 pupils are likely to be pupils who failed 3rd grade math exams in a previous year. On the other hand, the effect of the same Sector 1 on Sector 106 is 16, that is to say that out of the total native born pupils, 16 (or 7%) of them are likely to fail math exams of the current year.

Information concerning the direct effect shows for example, that out of the total native borns, the distribution by ethnic group is as follows;

Sect. No.	Ethnic	Distr.	No. of Pupils
5	Caucasian	79%	181
6	Black	12%	27
7	Hispanic/Caucasian	4.7%	10
8	Hispanic/Black	0.4%	1

A Sector Multiplier as was noted earlier, depicts the average number of transfers (from sector to sector) a pupil ought to achieve before leaving the system through a closure sector (i.e., Sectors 102-113). These multipliers are composed of the sum of the interdependency coefficients (α_{ij}) as denoted by equation no. 8. In this study however, the multipliers must be modified somewhat, inasmuch as the home environment and pupil attributes are sectors that are beyond the control of the school, even though they may influence the outcomes. For example, the multiplier for the average number of courses taken by a pupil (USA native) before taking an exam can be obtained as follows;

$$\sum_{i=63}^{101} \alpha_{ij} = 3$$

Hence, the multipliers of several sectors are provided in Table II below, for expository purposes:

Table II
Multipliers of Select Sectors

Sectors	$M = \sum_{i=63}^{101} \alpha_{ij}$
1	3.0004
3	3.0003
4	3.0006
5	3.0004
6	3.0005
7	3.0006
8	3.0006
20	2.9999
21	3.0006
25	2.9999
26	3.0034

C. Other Effects

The linear flow model can be regarded as a "performance evaluation" model portraying (through a quantitative "snapshots") the operation structure and outcomes of the system. In other words, this "stochastic" model can show the effect of a given sector on any other sector. Hence, the model can show the probability of a pupil whose teacher possesses a given level of education, upon the outcome of that pupil. For example, the probability that a pupil who was "educated" by a teacher with a BA degree (Sector 38), will pass 3rd grade (i.e., reading exams-Sector 105) is 0.169, whereas the probability of passing the same exam while being "taught" by a teacher possessing a PhD is 0.159 only. On the other hand, the probability of a pupil passing the Stanford Achievement Test (while being taught by a BA teacher) is 0.259, whereas the probability of the same pupil passing this exam while being taught by a teacher with MA + 45, (Sector 45) is 0.2729.

The model seems to indicate that the type of teaching license held by teachers has a greater impact on achievement than degrees held by the teachers. For instance, the probability of a pupil, whose teacher possesses a social science teaching certificate (Sector 58), passing the Stanford Achievement Test is 0.448, whereas the probability of that pupil is only 0.38, should that pupil be taught by a teacher holding a combined teacher license.

The effect of type of courses (taken by pupils) on the outcomes can be shown in a similar way. For example, the probability of a pupil, who has taken math skills (Sector 79), of passing the Stanford Achievement Test (Sector 109) is 0.2670, whereas the same pupil can increase his probability to 0.2698 by taking social studies 9 (Sector 89).

Although the model contains "sectors" which are beyond the control of the school (i.e., home environments), the effect of these sectors on the outcomes cannot be shown as of this writing because of inaccurate records concerning father education and occupation. Hence, such measurements are not provided in this report.

D. Improvement of the Model

Granted the validity of the conceptual view of the system and the theoretical model, the prototype model just discussed could be improved. In its current form, the model reflects a data recording problem concerning the home environment variables (Sector 1-37). To enhance the performance of the model, data concerning the home environment must be recorded (on the provided form) with greater care. It is also suggested that the stratified sample be enlarged so as to include high school pupils (grades 9-12). Finally, it is suggested that the "pegged" time period should correspond to the "examination cycle" of the school district in question.

The implementation of these data collection procedures will allow for the construction of an enhanced model portraying the entire operational structure of the school system. And such a descriptive model could then be used in conjunction with an operations research technique for the purpose of simulating alternative administrative policies (regarding pupil flow). Such policies could then be implemented for the purpose of attaining predetermined educational targets (goals) for an array of pupils.

V. SUMMARY

In this paper a pupil flow model that can be used to analyze the structure and processes of an educational service delivery system was presented. In the course of developing this prototype approach, discussions concerning the properties of the model, its components and the information that can be generated by the model were provided.

In constructing the model, we have conceptualized the school district to be a system that can be broken down into a set of relatively autonomous educational and administrative "sectors". The linkages among these sectors has been conceptualized in terms of organizational theories in general and intersectorial work flow in particular.

A stratified sample of pupils (flow and activities) was used as common units of analysis to denote such linkages among the units (sectors) of the system and to construct the model. The expository nature of this paper has precluded the extraction of an exhaustive set of information from the model. The paper has merely highlighted the capabilities of the model. In a subsequent working paper we will attempt to provide the reader with a comprehensive view of the structures and processes of the educational system as a whole.

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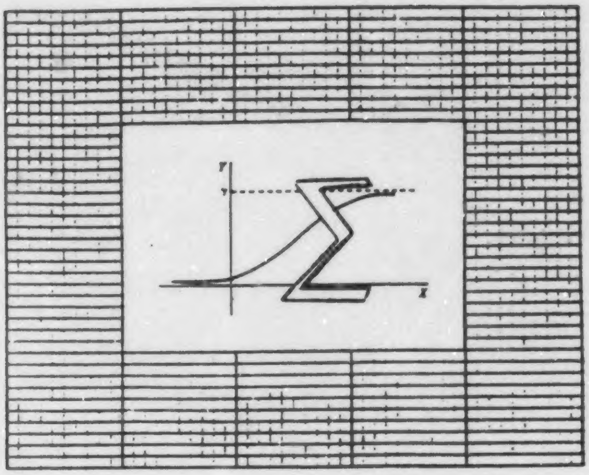

CHAPTER V.

SUMMARY AND CONCLUSION

V

SUMMARY AND CONCLUSION

In the preceeding chapters, the application of economic concepts and various quantitative methods to the problems of allocating of educational resources within school districts were discussed in length. In this chapter a few concluding remarks concerning this endeavor, are presented.

As was noted in Chapter I, an attempt was made to use proven educational economics and management science concepts along with corresponding quantitative methods while analyzing the resource allocation problems within school districts. Hence, threaded throughout this report are concepts concerning:

- educational production function
- efficacious resource allocation within school districts
- pupil flow within the existing operational structure of a school system.

Thus, three models were constructed. The first is a descriptive model, portraying the relationships between educational expenditures incurred, and the outcomes produced by school districts. A resource allocation procedure (goal programming) was then used in conjunction with this model. This amalgamated approach was used to determine the composition of financial resources needed to realize educational goals for various kinds of districts. Finally, a prototype model portraying operational structure of a school system and its outcomes was developed. Notice that the common units of analysis of this model are pupils, while the units of analysis of the former two models are school districts.

These models can then be used to:

- understand and clarify the predicaments in question
- complement the judgement process
- improve the decision making process (see Ignizio 1982).

The models developed and recorded herein are operational as far as L.I. school districts are concerned and results obtained have led us to draw some conclusions concerning the entire endeavor.

The central conclusion of the effort discussed thus far, is that an array of educational data can be reduced into a manageable set of equations through the application of the aforementioned concepts. Furthermore, it has been demonstrated that such equations (which summarize certain observed educational phenomona) can be used to address certain educational and/or policy predicaments. Specifically, it has been demonstrated in this study that:

- the relationships between educational means and ends can be quantified (into a model) through the application of an economic theory and its quantitative counterpart.

- multiobjective decision analysis techniques can be applied (in conjunction with the above mentioned model) to the problem of efficacious resource allocation within school districts so as to ascertain preemptive educational goals.

- the complex organizational structure of a school system and its outcome can be mathematically represented, through the application of an amalgamated approach which reconciles organizational theories and a management sciences technique.

The suggested refinements are based on the assertion that the effectiveness of any applied (or empirical) methodology,rests on its ability to produce statistically relevant features concerning existing and/or anticipated policy predicaments that may be faced by the educational system under study. Thus, to enhance the operational capability of the three models, some further work was suggested. For instance, the pupil performance model presented in Chapter II can be improved through the calibration of a retrospective model with interactive and lagged explanatory variables, whose coefficients are simultaneously estimated (for selected subset of equations) via an ML technique. The goal programming model (Ch. III) on the other hand, could be replaced and/or complemented by a "piece-wise" linearization technique. Finally, the pupil flow model (Ch. IV) can be improved through the enhancement of the data collection procedures.

In sum, the application of the methodologies discussed thus far should not be viewed as a mysterious process. Rather, it was demonstrated in the report, how an array of educational data can be reduced into a manageable set of equations through the application of educational economic concepts and quantitative methods. In other words, the aim of this research effort was to show how quantitative methods can be used to address major policy predicaments associated with the (prevailing) egalitarian educational philosophy (in the State of N.Y.), namely;

- What is the best composition of financial resources (by function) that would lead to a situation whereby a given type of school district would "produce" predetermined level of educational ends, while considering its pupils (and community) attributes.
- What administrative adjustments could be implemented by a given educational jurisdiction, in order to attain some predetermined (and unified) educational goals for an array of pupils (with diversed attributes).